TM 5-240

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

MAP COMPILATION COLOR SEPARATION AND REVISION

HEADQUARTERS, DEPARTMENT OF THE ARMY
SEPTEMBER 1962

[redacted]

TECHNICAL MANUAL No. 5-240

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C., *28 September 1962*

MAP COMPILATION, COLOR SEPARATION, AND REVISION

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CHAPTER 1

INTRODUCTION

Section I. PURPOSE AND SCOPE

1. Purpose

This manual provides a single text on the techniques of map compilation and drafting for the guidance of all personnel whose duties include map compiling, cartographic drafting, and map editing.

2. Scope

a. The manual covers the construction of map projections and grids; the compilation and revision of maps from aerial photographs or map manuscripts by specialized phases of topographic drafting; and the preparation of mosaics, annotated photographs, hasty maps, and other map substitutes. The details of general drafting included in TM 5–230 or the details of multiplex compilation described in TM 5–244 are not within the scope of this manual. The glossary includes definitions of terms used in this manual.

b. Users of this manual are encouraged to submit comments or recommendations for changes to improve the manual. All comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and proper evaluation. Comments should be forwarded directly to the Commandant, U.S. Army Engineer School, Fort Belvoir, Va.

c. Information contained herein is applicable without modification to both nuclear and nonnuclear warfare.

3. Safety

The map compilation, color separation, and revision techniques described herein utilize instruments, machinery, and certain chemicals. The utmost safety precautions must be exercised at all times to eliminate accidents and hazards. Safety precautions are noted throughout the manual wherever applicable.

Section II. CONSIDERATIONS

4. Responsibility

The Corps of Engineers is responsible for the execution and functioning of the Department of the Army mapping program, as set forth in AR 117–5 and TM 5–231.

5. Organization of Topographic Units

FM 5–188 describes the organization of engineer topographic units.

6. Elements of Map Compilation

Map compilation consists of—

a. Collection of available types of source material.

b. Evaluation and selection of the source material.

c. Adjustment of selected map material to the scale of compilation.

d. Adjustment and plotting of selected data onto a compilation base.

e. Engraving, inking, and preparation of map manuscript for reproduction.

7. Types of Maps Required

Military operations require various types of maps at different scales. The following general classifications are used to indicate which natural and manmade features are shown and how they are portrayed:

a. Topographic Maps. A topographic map presents relief or the vertical positions of features in measurable form as well as their horizontal positions. The vertical positions are normally represented by contours and elevation values. The elevation values are always referred to a mean sea level datum plane origin.

b. Planimetric Maps. A planimetric map presents only the horizontal position of features.

It is distinguished from a topographic map by the omission of relief in a measurable form.

c. Plastic Relief Maps. A plastic relief map is a standard topographic map printed on a plastic base which is shaped to indicate the vertical relief in the third dimension as represented by the contour lines, usually at an exaggerated scale.

d. Photomaps. A photomap is a reproduction of an aerial photograph or mosaic made from a series of aerial photographs on which additional data, such as arbitrary grid lines, marginal data, place names, route numbers, important elevations, boundaries, approximate scale, and approximate direction have been added.

e. Strip Mosaics. A strip mosaic consists of one strip of aerial photographs taken on a single flight.

f. Provisional Maps. Provisional maps are any maps which do not meet the standard design and specifications, such as hastily made line maps or air photos and foreign maps which have been reproduced in the field. They are used as emergency, nonstandard maps.

g. Classification of Maps. See TM 5–231 for more detailed discussion of the classification of maps.

8. Scale of Maps

Maps fall into the following categories:

a. Small Scale: 1: 600,000 and smaller.

b. Medium Scale: Larger than 1: 600,000, but smaller than 1: 75,000.

c. Large Scale: 1: 75,000 and larger.

d. Standard Military Map Scales: 1: 50,000, 1: 250,000, and 1: 1,000,000. See FM 21–31 for further details of the scales of topographic maps.

9. Military Uses of Maps

Maps at scales smaller than 1: 1,000,00 used by staffs for general military purposes. Maps at 1: 1,000,000 scale by staffs in strategic operations, suc movement, deployment, and supply o Maps at 1: 250,000 scales are used strategic purposes and in tactica they often serve as military road at 1: 100,000 and 1: 50,000 are use operations of infantry and suppc and for detailed planning by other ar services. Maps at 1: 50,000 are used b artillery for fire control and position loca by the infantry for mortar fire, selection of fields of fire, and blocking or defensive positions; and as battle maps by other arms. Although no longer a standard scale in military mapping, 1: 25,000 maps still exist (until full conversion to 1: 50,000 is completed), and are still used in some foreign countries as standard maps. Military city maps, showing all streets, principal buildings, bridges, utilities, and contours are normally published at the scale of 1: 12,500; they are used for tactical operations in densely built-up areas where more detail than shown on a 1 :50,000 scale map is required.

10. References

Appendix I lists army regulations, field manuals, and technical manuals on mapping. The Department of the Army supply manuals also list library reference sets for topographic units.

Section III. COLLECTION OF SOURCE MATERIAL

11. Background

a. Map compilation involves making a new map based on the following sources of information:

(1) Basic trig data.
(2) Survey field notes.
(3) Existing maps.
(4) Aerial photography.
(5) Classification survey.
(6) Other related material.

b. The collection and collation of source material is normally a function of the operations element of the topographic unit. This element evaluates the material and prepares compilation instructions which specify the material to be utilized and recommendations for their use (app. IV). The materials and instructions are then transmitted to the compiling element.

12. Basic Trig Data

a. Control Data Cards. The basic control data or trig data necessary for plotting onto the map base is generally given to the map compiler in the form of control data cards, one for each geodetic control point. Figures 1 and 2 are examples of control data cards. They con-

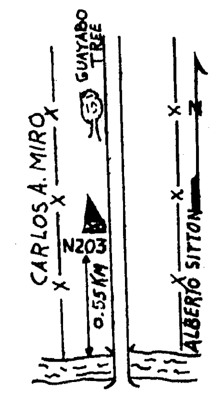
COUNTRY PANAMA	TYPE OF MARK Disk	DESIGNATION OF MARK N 20
PROVINCE OR STATE Chiriqui	ESTABLISHED BY (AGENCY) IAGS	ELEVATION 31.5258 (FEET) (M)
MUNICIPALITY David	AGENCY (CAST IN MARK) IAGS	ORDER First ~~(FINAL)~~ (PRELIM.)
LINE Concepcion to David	MARK IS STAMPED COTREG N 20 1949	DATUM Mean Sea Level

ON Located on the southwest side of the Carretera Inter-cana 2.7 miles N.W. from David Cervantes Park and 14.4 miles from Concepcion railroad station, 0.55 kilometers N.W. from -n Cristobal concrete bridge.

It is set on top and center of the concrete abutment of tension transmission tower.

It is: 0.60m. lower than the top of the road across this point.
7.50m. S.20°W. from the centerline of the road.
13.50m. S.55°E. from 5" guayabo tree on shoulder of the road.
2.20m. N.20°E. from south fence.

SKETCH



Reference to adjoining ground elevations

	North	South	East	West
15 meters	-0.50 on road	-0.10	+0.40	0.00
30 meters	-0.10	-0.20	+0.40	+0.20

(DESCRIBED) OR (RECOVERED) BY	AGENCY	DATE
Ruben Nunez	IAGS	June 1952

DA FORM 1 FEB 57 1958 DESCRIPTION OF BENCHMARK (TM 5-237

DESCRIPTION OR RECOVERY NOTES

The following suggestions are offered as a guide to Engineers describing or recovering survey stations. Fill in all blanks on front of card, if items are not applicable, write "None." The items (Elevation), (Order), and (Datum) will be disregarded by the field engineer.

1. STATION MARKS AND REFERENCES: Describe each mark, provide identity of agency cast in mark; exact letters and/or numbers stamped on the mark; the object in which the mark is set; whether the mark is above or below ground and approximate elevation above or below some permanent feature such as highest point of hill, top of rail, surface of highway, etc. If the mark cannot be located, provide reasons for nonrecovery. Marks should not be reported as destroyed unless positive evidence of their destruction is available.

2. PHOTOGRAPHIC IDENTIFICATION: Provide measured distances to and descriptions of objects in the immediate vicinity which might be identifiable on an aerial photograph. Photos taken by hand-held cameras or identification of the station on aerial photography should be furnished when available.

U. S. GOVERNMENT PRINTING OFFICE: 1957 O -420958

Figure 1. Vertical control card.

COUNTRY	TYPE OF MARK	STATION	
HAITI	Disk	AUX CAYES, N.B.S. (SGC-IAGS,1947)	
LOCALITY	STAMPING ON MARK	AGENCY (CAST IN MARK)	
AUX CAYES	"N. Base 1947"	Inter-American Geodetic Survey	
LATITUDE	LONGITUDE	DATUM	ELEVATION
18° 16' 13.835"	73° 51' 38.854"	1927 NAD	133.58 ~~(FEET)~~ (METERS)
NORTHING	EASTING	GRID AND ZONE	ORDER / ESTABLISHED BY
2 020 367.85	620 422.42	18 Clarke 1866	1st / IAGS
NORTHING	EASTING	GRID AND ZONE	DATUM
218 277.75	250 378.94	Lambert for Haiti	Mean Sea Level

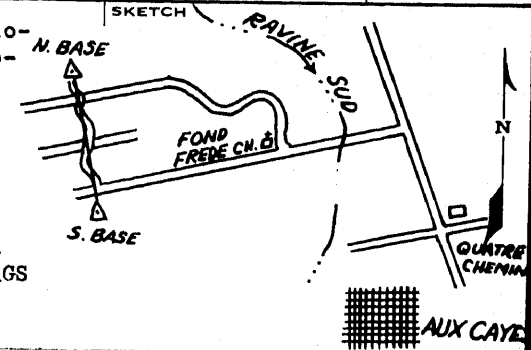
OBJECT	DIRECTION	MAG. BEARING	GEODETIC AZIMUTH	DISTANCE
DOUYON	000° 00' 00".00		05° 57' 28".65	17,05
Ref. Mk. No. 1	2 41 38		08 39 07	1
Ref. Mk. No. 2	278 23 12		284 20 41	12.

DESCRIPTION

Located on the plain of Torbeck about 16 kilometers northwest of the town of Aux Cayes; 9 kilometers from Mapou Simon along the baseline road; and 2½ kilometers north of Carrefour Tuffet. Station is on a small rise approx. 8 meters east of the centerline of the baseline road.

Station is marked by an IAGS triangulation disk stamped "N. BASE 1947" set in a 12 x 12 inch concrete monument. The underground mark is an IAGS triangulation disk set in the upper surface of a boulder 3 feet underground.

SKETCH



FOLD

Reference Mark No.1 is an IAGS disk with arrow pointing to the station, set in a 10 x 10 inch concrete monument 14.158 meters southwest of the station.

Reference Mark No. 2 is an IAGS disk with arrow pointing to the station, set in a 10 x 10 inch concrete monument 12.583 meters southeast of the station.

To reach the station from Aux Cayes, follow Jeremie road to a point 2 kilometers past the Quatre Chemin Army Post. At this point turn west onto a narrow road which passes over the dry stream bed of Ravine du Sud and continue to the Fond-Frede Church. Turn north at Church and follow rocky road for 5 kilometers to the open country. After reaching open country, turn left and continue to fork. Bear left at fork and follow road to Carrefour Tuffet turning north (right) 3/4 kilometer before reaching Carrefour Tuffet onto baseline road. Follow baseline road 2½ kilometers north to station.

The station is a new station established by IAGS.

(DESCRIBED) OR ~~(RECOVERED)~~ BY	AGENCY	DATE
Julio Mendez	IAGS	June 1947

DA FORM 1 FEB 57 1959 DESCRIPTION OF HORIZONTAL CONTROL STATION (TM 5-237)

Figure 2. Horizontal control card.

tain a detailed description and sketch of the point, its relative orientation with respect to other control points, and other data. When such survey information is established in the field, the cards are sent to the topographic computing unit, which converts that information for use in plotting on the map. See TM 5–237.

b. Trig Lists. Trig lists (see TM 5–237) are published sets of control data cards, usually arranged according to the location of the control points within the limits of map sheets of large-scale map series. They are used by artillery units for location of weapons, as well as by topographic units employed in map compilation. They may be assembled photographic copies of the control data cards for a given area or may be a tabulated form of the control data as shown in figure 3. The control data cards give sufficient information to the surveyor for recovery of the control stations in the field, whereas the tabulated trig lists also contain the necessary information for plotting the control data on the map manuscript.

13. Survey Field Notes

a. Surveying information pertaining to control obtained in the field is transmitted to the computing element of a topographic unit where it is converted into tabulations of rectangular coordinate values to be plotted on the map manuscript. Occasionally, plane table sheets may also be used for this purpose. Plane table sheets (fig. 4) are usually accurate sources of information.

b. Office records related to data on which military maps are based are important to the topographic draftsman. These records include transcriptions from field and office computations giving coordinates (both geographic and grid) of control stations, distances and azi-

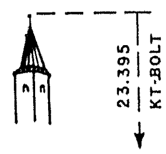
COUNTRY AUSTRIA SHEET NO. 138 — STA. NO 206

NORTHING OR LATITUDE	EASTING OR LONGITUDE	GRID OR DATUM
47°24'34.267"	16°29'59.504"	EUROPEAN
5,251,866.15	613,157.96	UTM 33 EUROPEAN
		UTM
5,252,207.770	12,586.910	AGK 34° HRMNSKGL

STATION: Rattersdorf, parish church knob — ORDER: Dg ELEV: 329.11m

Station is the center of the knob on the Romar Catholic parish church in Rattersdorf. Elevation refers to center of knob.

SKETCH



COUNTRY AUSTRIA SHEET NO. 138 — STA. NO.206A

NORTHING OR LATITUDE	EASTING OR LONGITUDE	GRID OR DATUM
47°24'34.402"	16°29'59.362"	EUROPEAN
5,251,870.25	613,154.89	UTM 33 EUROPEAN
		UTM
5,252,211.920	12,583.910	AGK 34° HRMNSKGL

STATION: Rattersdorf, parish church tower bolt — ORDER: Dg ELEV: 295.71 m

Station is the tower bolt in the east wall of the church, 2.505 m. high, 10.10 m. north of the south-east corner. It is the reference mark for "Rattersdorf, parish church, knob." Elevation refers to center of bolt.

SKETCH

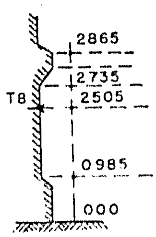


Figure 3. Trig list.

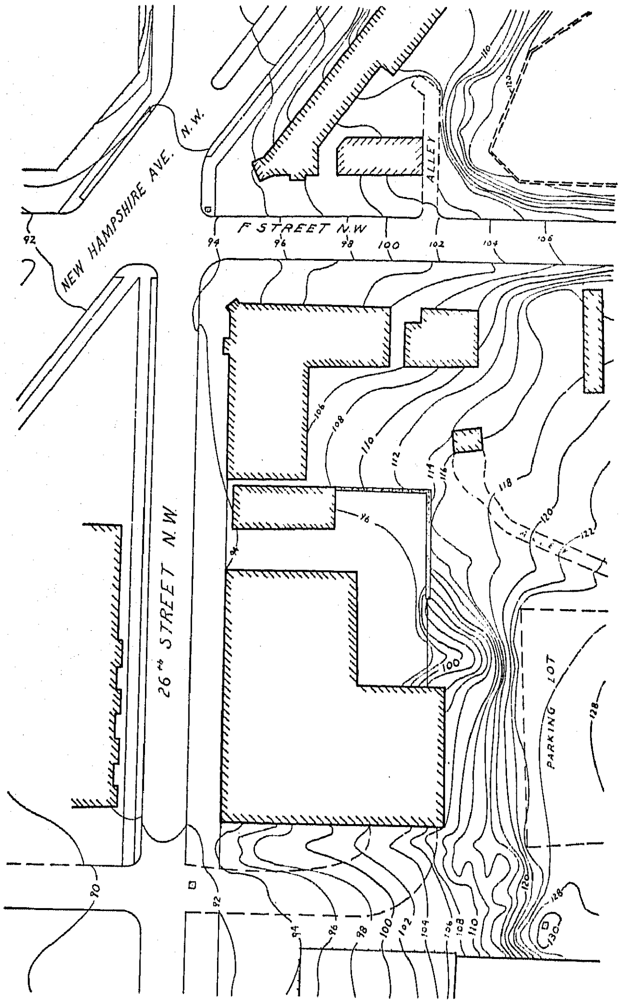


Figure 4. Plane table sheet.

muths between them, and their elevations. Also important are the field notes normally recorded in special field notebooks or on special forms and all computations made by field parties at field headquarters. See TM 5–234 and TM 5–237 for the details of office records.

14. Existing Maps

In peacetime the Corps of Engineers, through the Army Map Service and topographic units, is continuously engaged in compiling and revising maps of all potential combat areas. The emphasis is placed on securing a complete file of map source material which will be available for reproduction and distribution in time of war or other emergency. In addition, existing map source material prepared by other agencies may also be available for other areas. For example, road maps, city plans, tax maps, or utility plans may be procured through civil government agencies. In foreign areas, military maps may be secured by the intelligence unit either through the exchange of map material between allied forces or through captured enemy documents. In any area to be mapped, the intelligence unit will gather all available existing maps and furnish this information to the operations element of the topographic unit.

15. Aerial Photography

a. Availability. Photographs for mapping are available from the files accumulated by the Chief of Engineers peacetime mapping program. Supplemental photographs of more recent coverage may also be available through the files of the Intelligence and Mapping Division, OCE, in the form of either photography taken specifically for mapping purposes or reconnaissance photography taken for intelligence purposes. The intelligence division publishes accession lists of indexes periodically which may be consulted to determine recent coverage available (fig. 5).

b. Procurement.

(1) The Corps of Engineers is responsible for the planning and procurement before new photography is flown, and the Air Force will process the films and initially evaluate their suitability for mapping. The Corps of Engineers makes the final evaluation. Two sets of transparent glass-plate prints (diapositives) and two sets of paper prints are made for each exposure of photography, after which the film is sent to the Assistant Chief of Staff, Intelligence, U.S. Air Force, Washington 25, D.C., for storage.

(2) The collection of photographic source material is normally a function of the operations element of the topographic unit (see TM 5–243). When prints are pulled from the theater file for permanent use, a replacement set is ordered from the Air Force. Sometimes duplicate negatives are requested for the top templets in rectification for photomapping.

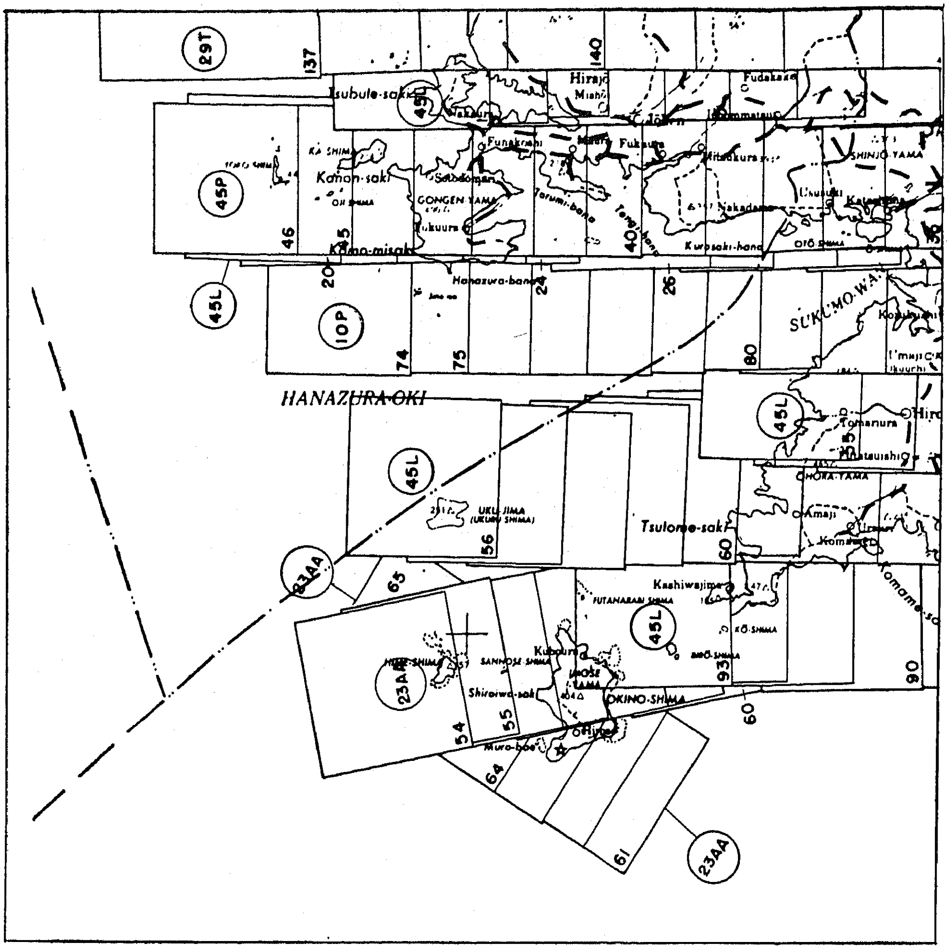


Figure 5. Photo coverage index.

16. Classification Survey

a. The classification survey performed in the field prior to map compilation involves the use of aerial photographs and provides information required for the compilation of a map. The classification survey consists of—

(1) Identifying and classifying, as necessary, the physical and cultural features to be mapped.

(2) Indicating such data by symbols and notes added to aerial photographs.

(3) Securing ground photographs of certain features.

(4) Securing information not directly obtainable from the aerial photographs.

(5) Writing a report covering the survey.

b. Classification surveys become of prime importance when surveys are conducted far in advance of map compilation or when surveying in areas remote from the place where the compilation is being conducted. The need for such a survey will be determined by the operations and planning staff of the topographic unit. Detailed instructions for carrying out the functions of a classification survey are given in TM 5–234.

17. Other Related Material

Source material such as the following will provide data for compilation of maps: Intelligence reports and studies; reconnaissance reports; gazetteers; transportation timetables; travel manuals, guides, and route books; statistical handbooks and yearbooks; geographical and engineering publications; industrial and trade journals; census reports; and postal guides. For information on sources in foreign areas, see TM 5–248.

CHAPTER 2

PREPARATION OF THE COMPILATION BASE

Section 1. PROJECTIONS

18. Considerations

A map is a graphic representation of a portion of the earth's surface to some convenient scale on a plane and shows the relative positions of points and natural features of the earth. Any attempt to represent the round earth on a flat surface requires some distortion of features. One of the first problems in mapmaking, then, is to find some form of representation that will minimize those distortions affecting the intended use of the map. The projection is the method by which the surface of the earth or the celestial sphere is represented on a plane.

19. Latitude and Longitude

a. Any selected reference system is a series of lines on a map representing an imaginary set of these same lines on the earth's surface. The almost universal plan for these lines upon the earth's surface is to adopt a system of spherical coordinates based upon the Prime Meridian, or great circle through Greenwich, England, to which longitude, or angular distance east and west, is referred, and the equatorial plane to which angular distance north and south, or latitude, is referred. The coordinates of 46° N. 60° W. (fig. 6) indicate how the latitude and longitude of a point on the earth's surface are measured.

b. Although Greenwich, England, is commonly used as a prime meridian of longitude, other prime meridians of longitude are also used in various countries. Since the Meridian Conference of 1884, Greenwich has been used by almost every nation in the world.

20. Projections Used in Military Mapping

a. Large- and medium-scale military mapping uses the modified Transverse Mercator projection between 84° north latitude and 80° south latitude. This projection is developed on a series of secant cylinders, whose longitudinal axes are perpendicular to the equatorial plane. These cylinders are spaced 6° apart, with the first cylinder having a central meridian of longitude 3° E. A zone 6° in longitude extending from the 84° N. latitude to the 80° S. latitude is then projected from the earth's surface onto the enveloping cylinders, as a radial projection from the center of the earth. The projected zones are opened up into a flat plane, and placed next to each other in sequence in the easterly direction. To make the map conformal and continuous, the parallels of latitude are expanded so that the scale between latitudes and longitudes is the same at any given point on the map. The resulting map is similar in appearance to a standard Mercator map. See TM 5–241 for a detailed discussion of the Transverse Mercator projection.

b. Small-scale military maps utilize the Lambert conformal conic projection between 80° north latitude and 80° south latitude. This projection is a secant cone type of projection which intersects the earth at two parallels of latitude. All projection is from the origin (center of the earth) through the points on the surface of the earth to the cone. In constructing the Lambert projection, a central meridian or north-south base line is selected and perpendiculars constructed on the central meridian at a distance equal to the scale spacing of the parallels representing the north and south projection neatlines. One half the length of the north neatlines is then plotted along the upper perpendicular on each side of the central meridian and repeated for the southern neatlines. The intersections are connected to establish the east and west boundaries of the projection. The projection is then divided into 10-minute quadrangles, using proportional dividers.

c. Large- and medium-scale military maps employ the Polar Stereographic projection in the north polar area from 84° to 90° latitude and in the south polar area from 80° to 90°

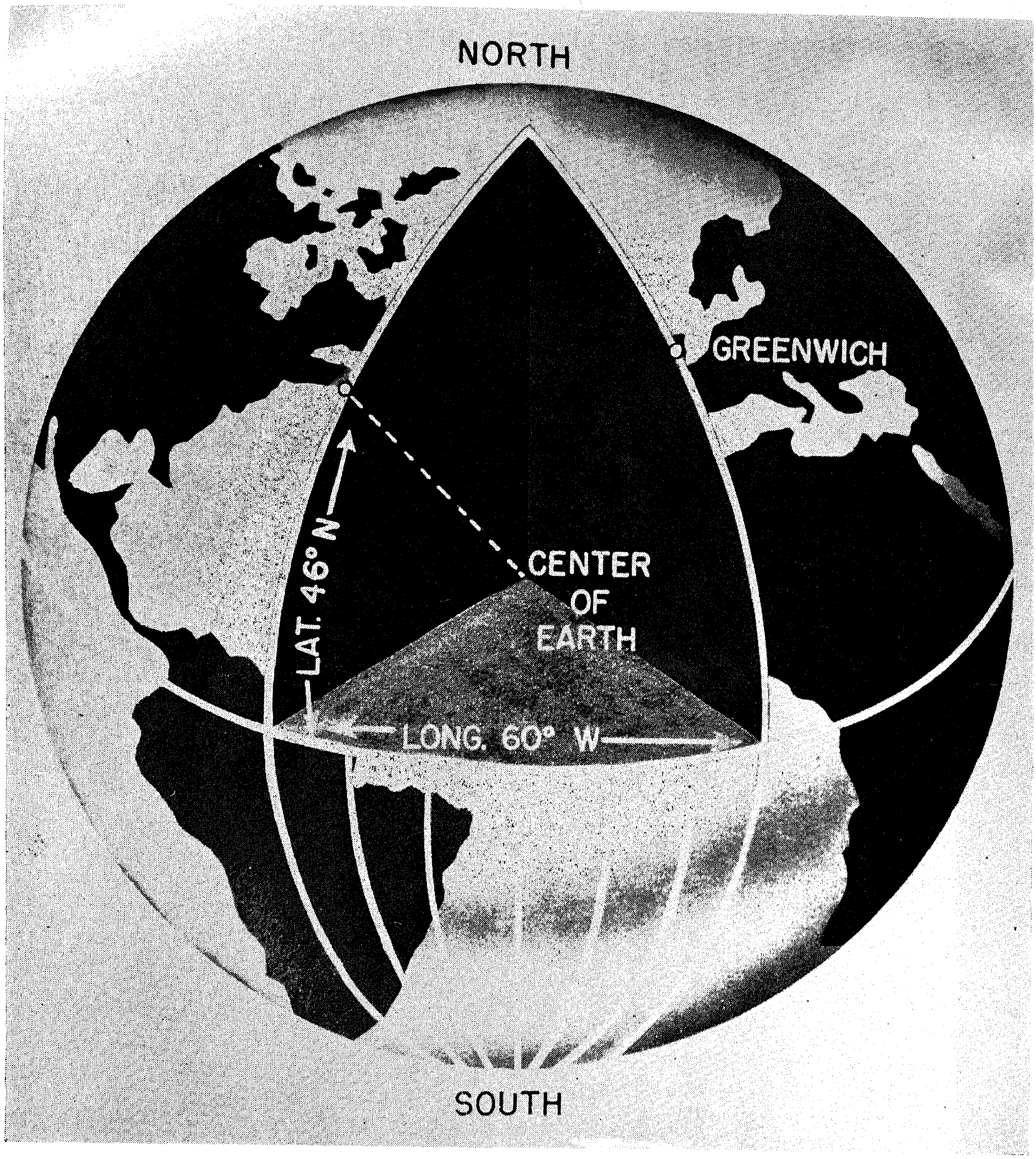


Figure 6. Globe showing latitudes and longitudes.

latitude. Small-scale maps employ the Polar Stereographic projection in both the north and south polar areas from the 80° latitudes to the 90° latitudes. The Polar Stereographic projection is made by projecting the meridians and parallels of latitude onto a plane which, for all intents and purposes, may be considered tangent to the earth at either pole. The source of the projection rays is at the opposite pole from the one to which the plane is tangent. The meridians appear as straight lines emanating from the pole. The parallels of latitude appear

as concentric circles whose distance from one another increases with the distance from the poles. See TM's 5–241–1 through 5–241–9 and 5–241–11 through 5–241–16 for a detailed discussion of the Polar Stereographic projection.

d. The Polyconic projection formerly used for military mapping has been made obsolete by the adoption of the TM and PS projections. The Polyconic projection, as its name applies, is developed on a series of cones, a different cone being used for each parallel of latitude. This projection is still used by nonmilitary agencies.

21. Grids

For information on grids, see TM's 5–241–1 through 5–241–9 and 5–241–11 through 5–241–16.

Section II. CONTROL

22. Types of Control

a. Definition. Control is the coordinated and correlated dimensional data used in geodesy and cartography to determine the positions and elevations of points on the earth's surface or on a cartographic representation of that surface. Control is a collective term for a system of marks or objects on the earth or on a map or a photograph, whose positions or elevations, or both, have been or will be determined. Control usually consists of the coordinates and elevations of certain strategically located points, in the distance between two such points, the difference in elevation between two such points, or the direction of a line expressed in terms that are useful in making measurements from the terrain or in making maps.

b. Control Station. A control station is an object or mark on the ground of known position or elevation, or both, in a network of ground control. Control stations constitute the framework by which map details are fixed in their correct position, azimuth, elevation, and scale with respect to the earth's surface.

c. Control Point. A control point is an image or point on a photograph or map that represents a point of known position or elevation, or both, in a network of control. Control points are classified according to the method by which they are established, i.e., ground control or photogrammetric control; according to their functions, i.e., tie point or supplementary point; or according to their accuracy, i.e., first, second, or third order.

d. Horizontal and Vertical Control. Control may be classified as horizontal or vertical. Horizontal control determines horizontal positions only, as with respect to parallels and meridians, or to other imaginary lines or reference on the earth. Vertical control determines elevations only, with respect to an imaginary level surface representing sea level or some other constant elevation.

e. Ground Control. Ground control is the coordinated and correlated dimensional data obtained by ground surveys and used in map compiling to determine the orientation of photographs with respect to the earth or a map. To have any value in map compiling from aerial photographs, ground control must always be photoidentifiable.

23. Ground Control Plots

a. Purpose. Control plots include all drawings on which horizontal control stations are plotted for the purpose of serving as a base in making topographic or other maps. In some areas, geodetic control is of sufficient density so that supplementary control is unnecessary. When geodetic control is insufficient for compilation purposes, additional control must be established either by survey methods or by photogrammetric methods. As soon as basic control data are made available, they are plotted on the compilation base. A complete control sheet shows all ground control points established by surveying methods and in addition, all adjusted control points determined by photogrammetric methods.

b. Control Data Lists. All available horizontal stations within the map limits that are suitable for plotting on the map manuscript are tabulated in special booklets known as trig lists. These lists are merely catalogue copies of the data control cards for the control points of the area (par. 12*b*) and give the horizontal and vertical locations for each point with respect to the geographic coordinates and the grid system being used. The compilation section then uses these data to plot the survey ground control on the compilation base.

Section III. PLOTTING TECHNIQUES

24. Compilation Sheets

a. Steps in Preparation. Maps are prepared by plotting terrain features upon a map manuscript according to available topographic information and survey control data. The first step in the preparation of the compilation base is the construction of the grid for the area to be shown and, if necessary, the corresponding meridians and parallels at the desired intervals. The gridding of a map is a drafting operation involving the construction of grid frames, drawing in grid squares, plotting the geographic coordinate references, and marking off neatlines. Neatlines are the lines that bound the topographic information appearing on the map itself and are usually parallels and meridians. All ground-established horizontal control points are next plotted by a coordinate method on the compilation (base) sheet. To the control points thus established, available data from other instrumental surveys and aerial photo triangulation are added in an effort to subdivide the sheet into small sectors with lines of supplemental control. Topographic detail is later added to the supplemental control. To perform some of the above operations, the topographic draftsman must be able to use tables of intersection and perform simple mathematical computations.

b. Grids Versus Geographic Coordinate References. The geographic coordinate references at the corner of a map sheet orient the area covered by the map. The representation of comparative relations between geographic data and grid data on a map requires methodical plotting. One plotting procedure involves construction of the separate geographic coordinate references based upon the central meridians of each sheet. In a second procedure, the grid is drafted first; then the geographic coordinate references are plotted from the grid. The second is the more commonly used method. Since all grid squares appearing on maps of the same scale are identical in size irrespective of the geographical location of the map, this procedure insures that both the grid and the geographic coordinate references will remain on the same projection.

c. Grid Plotting Methods. Since the grid is merely a system of squares to some selected scale, a master grid pattern can be prepa[red] accurately on a dimensionally stable medi[um] and will then fit any projection at the sa[me] scale. Usually the master grid is drawn [o]
square larger in each direction than the sh[eet] lines. Accurate copies are then produced o[n] dimensionally stable medium by the lit[ho]graphic process. The sheet lines for each m[ap] sheet outlining the limits of the work can t[hen] be drawn in on a copy of the master grid by [the] arc and tangent method and can serve as [the] compilation base. Another copy of the mas[ter] grid can be used for the final drafting mediu[m]. One grid, therefore, serves as a common b[ase] for all maps of the same scale. When the ma[p is] finally ready for reproduction, the grid li[nes] outside the limits of the sheet lines can [be] masked out before the sheet is photographed.

d. Accuracy. The final accuracy of any m[ap] depends upon the accuracy of the grid, proj[ec]tion, and control plotting on the compilati[on]. To maintain the required accuracy, the g[rid] must be plotted to 0.13 mm (0.005 inch), [the] projection must not be in error by more th[an] 0.13 mm when referred to the grid, and [the] control must be within 0.13 mm when refer[red] to the projection.

25. Construction of the Compilation Base

a. Construction of the Grid Board. The c[on]struction of the map grid is a drafting fu[nc]tion; for information concerning general dra[ft]ing techniques, see TM 5-230.

(1) The approximate center of the sh[eet] is located by drawing diagon[als] through the sheet corners. At the [in]tersection of the diagonals (fig. [ ] HH' and VV' are made perpendicu[lar] to each other and approximately p[ar]allel to the sides of the sheet.

(2) At the compilation scale of the m[ap] distances are computed from the c[en]ter of the sheet to the position of [the] grid lines nearest the outside edges [of] the sheet and are so marked with [a] beam compass as arcs OA, OB, [etc.]

(3) Using the two beam settings of (above, in turn, from points D then and C then B, eight arcs are describ[ed] forming the four intersections rep

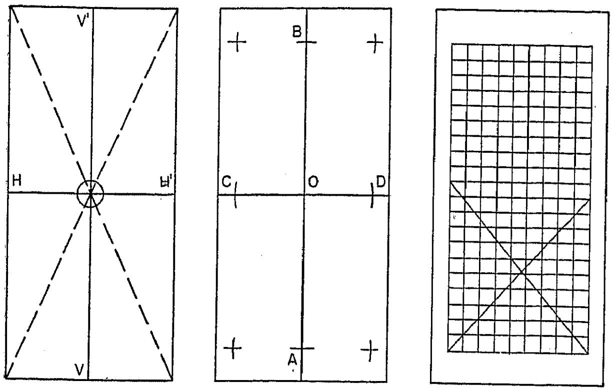


Figure 7. Drafting a UTM grid.

senting the corners of the grid frame. The two diagonals are tested for squareness before proceeding.

(4) The corners are connected with straight lines that must pass through points A, B, C, and D. The intermediate lines are then drawn by subdividing all four outside grid lines until the proper number of intervals is obtained, and connecting the opposite edges with straight lines parallel to the grid frame.

(5) The grid is tested for squareness and general suitability by measuring the length and the intersection along different diagonals drawn at convenient places on the sheet.

b. Use of the Coordinatograph. The coordinatograph or rectangular coordinate plotter, is an instrument used to plot precise measurements. It is a table-like instrument containing a plotting arm across the surface for plotting x- and y-directions. The micrometer movement of the arm is geared along the glide-ends for precise adjustment and is equipped with needle, pencil, and inking points for plotting and drawing directly on the surface of the map or copy. The instrument is also equipped with interchangeable scales so that almost any desired combination of ratios can be obtained. In the preparation of maps, the coordinatograph is indispensable for the construction of grid nets and the plotting of ground control.

c. Geographic Coordinate Reference Intervals. Once the grid has been drawn, the next step is to locate the parallel and meridian intersections precisely according to the grid values of their geographic coordinates. Mapping instructions specify the minimum interval between geographic coordinate intersections appearing on standard maps. The minimum interval of plotted intersections required for large scale maps are—

Scale	*Interval*
1:25,000	2½ minutes
1:50,000	5 minutes
1:100,000	10 minutes
1:250,000	15 minutes

(1) It is usually sufficient to plot only the four corners of a 7½-minute sheet at 1:25,000 scale. The 15-minute sheets at 1:50,000 scale require that the intermediate 5-minute geographic coordinate references be plotted. A 30-minute sheet at 1:100,000 scale requires plotting the 10-minute intersections.

(2) When 2½-minute ticks are desired between plotted 5-minute and 10-minute intervals, they are obtained by subdividing straight line connections between the plotted 5-minute and 10-minute ticks.

d. Tables of Coordinates and Intersections. To plot the geographic coordinate references, the draftsman must know the grid distances (east or west and north or south) from a major grid intersection to the geographic coordinate. The transformation of geographic coordinates into grid coordinates is a topographic computing function. Use of prepared tables simplifies the mechanics of these transformations. See TM's 5–241–1 through 5–241–9 and 5–241–11 through 5–241–16 for a detailed explanation of conversion computations. For the normal geographic intervals appearing on maps, however, tables for the grid coordinates of the geographic positions have been compiled by the Corps of Engineers. These tables of coordinates and intersections have been compiled for 5-minute and 7½-minute intervals in accordance with the 5 spheroids (Clark 1866, Clark 1880, International, Bessel, and Everest) and according to definite limits of latitude. See appropriate listings of manuals of TM 5–241 series in appendix I. The given values of tables are accurate to within 0.1 meters and are therefore accurate enough for plotting purposes. When greater accuracies are desired, values

must be obtained by conversion computations. Extracting grid values from tables of intersections is a computing function, and is furnished the topographic draftsman on the form (DA Form 1941) shown in figure 9.

e. Distances from Corner Geographic Coordinate Reference to Grid Intersections. The geographical location of a map area is identified by its limiting meridians of longitude and parallels of latitude. When the geographical coordinates of the intersections of these meridians and parallels are expressed in grid equivalents, they provide a means of determining the metric distances to the first 1,000 meter grid line appearing within the map area. Taking 41°30′00″ N. 74°07′30″ W. as the southwest corner of the map sheet, the equivalent grid values become 573,032.3mE. and 4,594,-421.0mN. (fig. 8). See TM's 5–241–1 through 5–241–9 and 5–241–11 through 5–241–16 for further details.

f. Plotting the Projection. Instructions for plotting graticules should be keyed to DA Forms, numbers 1932, 1933, and 1941 (figs. 9, 10, and 11). For further information, see TM 5–237.

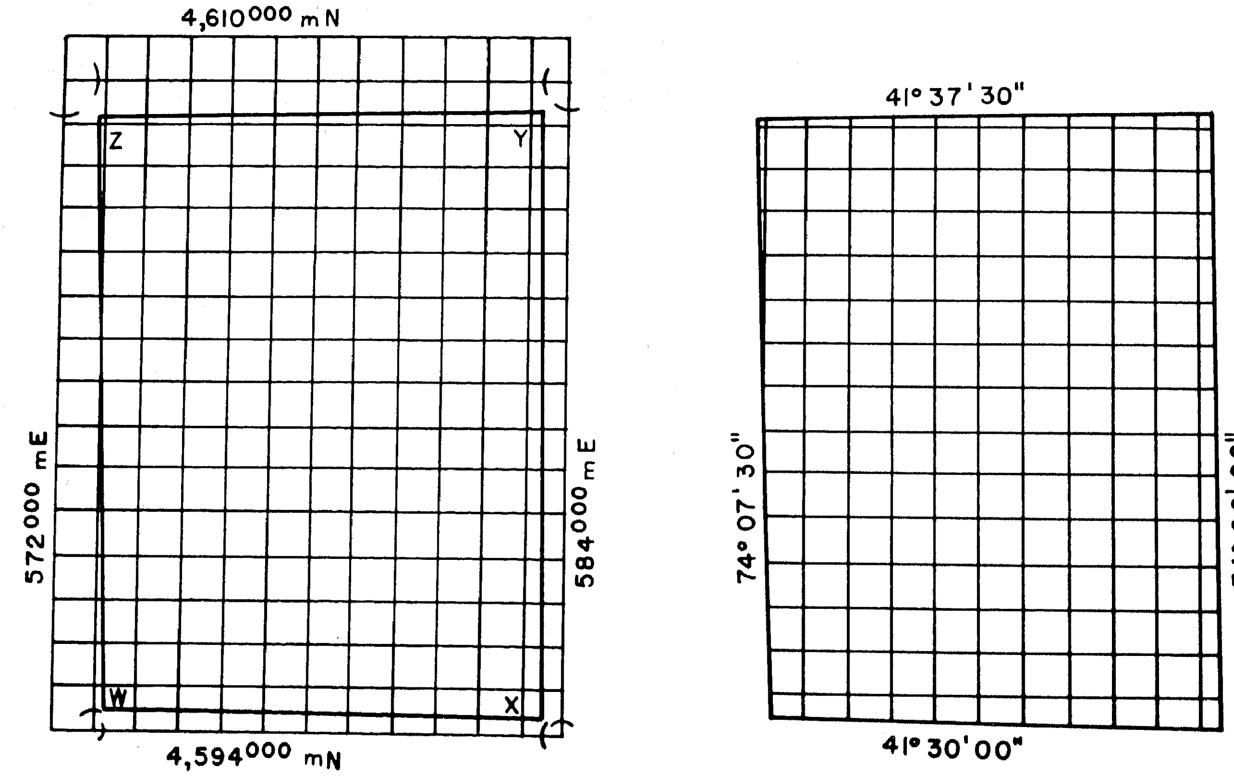


Figure 8. Plotting geographic coordinate references.

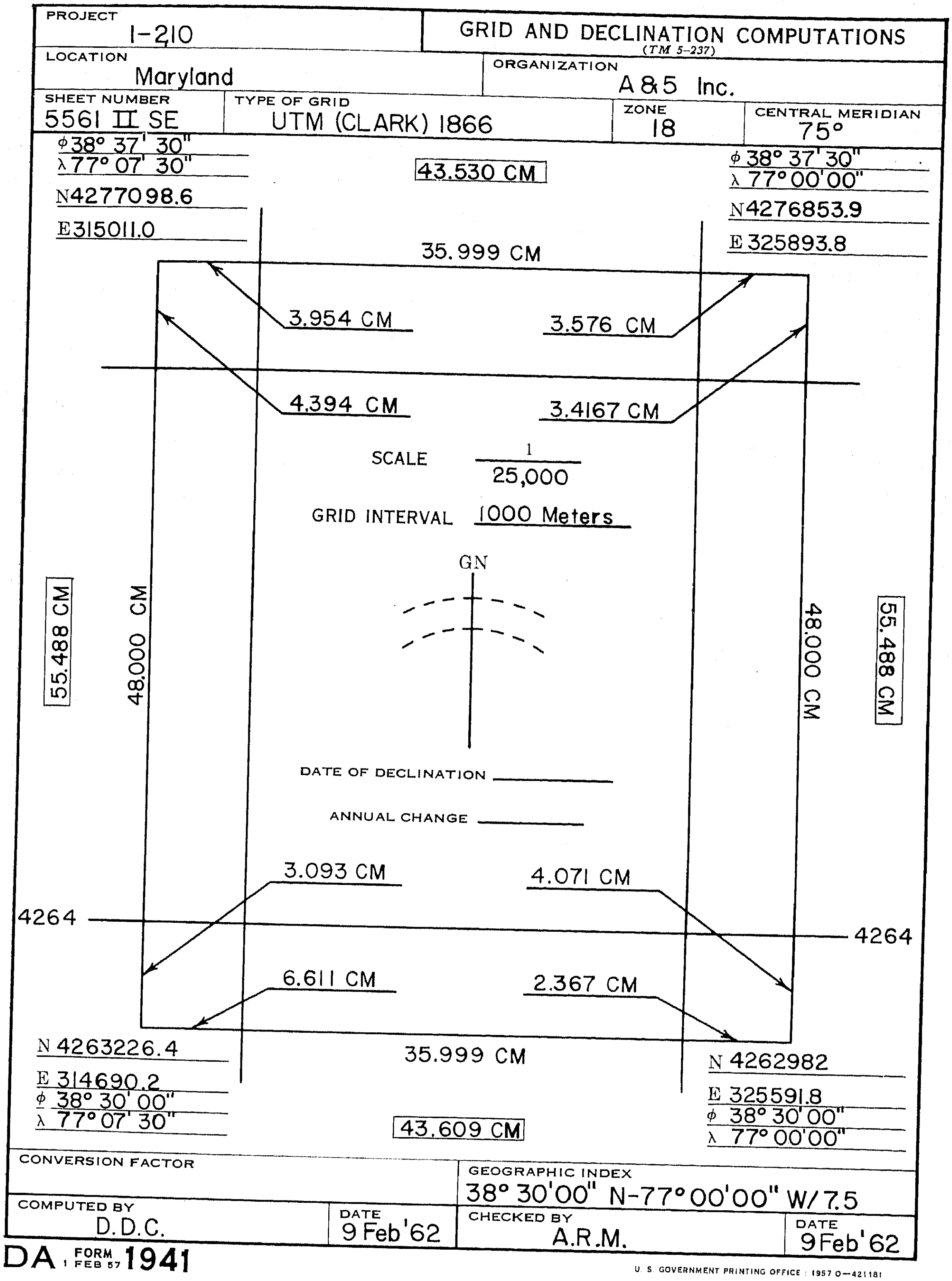


Figure 9. Grid and declination computations.

PROJECT V-8059	U. T. M. GRID COORDINATES FROM GEOGRAPHIC COORDINATES (TM 5-237)			
LOCATION Oklahoma	ORGANIZATION A&S Inc.			
SPHEROID Clarke 1866	CENTRAL MERIDIAN 99°00'	ZONE 14	UNIT Meter	FE 500,000 m.

Station	Hypothetical (Method 2)			Station	Hypothetical (Method 3)		
ϕ	34° 15' 34".742	λ	96° 02' 43".158	ϕ	34° 15' 34".742	λ	96° 02' 43".158
(I)	3 790 750.848	$\Delta\lambda$	02° 57' 16".842	(I)		$\Delta\lambda$	02° 57' 16".842
(II)	3 489.927	p^2	1.1314241	(II)		p^2	1.1314241
(III)	2.137	p^4	1.2801	(III)		p^4	
A_6	0.001			A_6			
(IV)	255 744.423	p	1.0636842	(IV)		p	1.0636842
(V)	37.005	p^3	1.203478	(V)		p^3	
B_5	-0.025			B_5			
N	3 794 702.17	E	772 075.81	N	3 794 702.17	E	772 075.81

Station	1			Station	2		
ϕ		λ		ϕ		λ	
(I)		$\Delta\lambda$		(I)		$\Delta\lambda$	
(II)		p^2		(II)		p^2	
(III)		p^4		(III)		p^4	
A_6				A_6			
(IV)		p		(IV)		p	
(V)		p^3		(V)		p^3	
B_5				B_5			
N		E		N		E	

Station				Station			
ϕ		λ		ϕ		λ	
(I)		$\Delta\lambda$		(I)		$\Delta\lambda$	
(II)		p^2		(II)		p^2	
(III)		p^4		(III)		p^4	
A_6				A_6			
(IV)		p		(IV)		p	
(V)		p^3		(V)		p^3	
B_5				B_5			
N		E		N		E	

COMPUTED BY W. C. A.	DATE 8 Sept 53	CHECKED BY RAS	DATE 8 Sept. 53

DA FORM 1 FEB 57 1932

Figure 10. UTM grid coordinates from geographic coordinates.

PROJECT	GEOGRAPHIC COORDINATES FROM U. T. M. GRID COORDINATES (TM 5-237)
V-8059	

LOCATION	ORGANIZATION
Oklahoma	A & S, Inc.

SPHEROID	CENTRAL MERIDIAN	ZONE	UNIT	FE
Clarke 1866	99°00'	14	Meter	500,000 m.

Station	Hypothetical (Method 2)			Station	Hypothetical (Method 3)		
N	3 794 702.17	E	772 075.81	N	3 794 702.17	E	772 075.81
φ'	34° 17' 43."032			φ'	34° 17' 43."032		
(VII)	1734.731	q^2	0.07402525	(VII)		q^2	0.07402525
(VIII)	22.64	q^4	0.0054797	(VIII)		q^4	
D_6	− 0.0001			D_6			
(IX)	39118.040	q	0.27207581	(IX)		q	0.27207581
(X)	309.686	q^3	0.02014048	(X)		q^3	
E_5'	+ 0.0068			E_5			
Δφ	02' 08."290	Δλ	02° 57' 16."842	Δφ	02' 08."290	Δλ	02° 57
φ	34° 15' 34."742	λ	96° 02' 43."158	φ	34° 15' 34."742	λ	96° 02 4...

Station	①			Station	②		
N		E		N		E	
φ'				φ'			
(VII)		q^2		(VII)		q^2	
(VIII)		q^4		(VIII)		q^4	
D_6				D_6			
(IX)		q		(IX)		q	
(X)		q^3		(X)		q^3	
E_5				E_5			
Δφ		Δλ		Δφ		Δλ	
φ		λ		φ		λ	

Station				Station			
N		E		N		E	
φ'				φ'			
(VII)		q^2		(VII)		q^2	
(VIII)		q^4		(VIII)		q^4	
D_6				D_6			
(IX)		q		(IX)		q	
(X)		q^3		(X)		q^3	
E_5				E_5			
Δφ		Δλ		Δφ		Δλ	
φ		λ		φ		λ	

COMPUTED BY	DATE	CHECKED BY	DATE
W. C. A.	8 Sept. 53	RAS	8 Sept 53

DA FORM 1 FEB 57 1933

Figure 11. Geographic coordinates from UTM grid coordinates.

g. Alternate Method of Plotting the Corners. At times, the scale of the map does not permit direct scale measurement of the coordinates and a proportioned plotting must be made (fig. 12). Choose a length easily divisible and slightly longer than the span between the grid lines. Pivot the scale, in position (1), with the zero point on one grid line until the selected graduation falls on the other grid line. Measure along the scale to the calibration which marks 0.032 of the selected distance between the vertical lines of the grid and make a pin

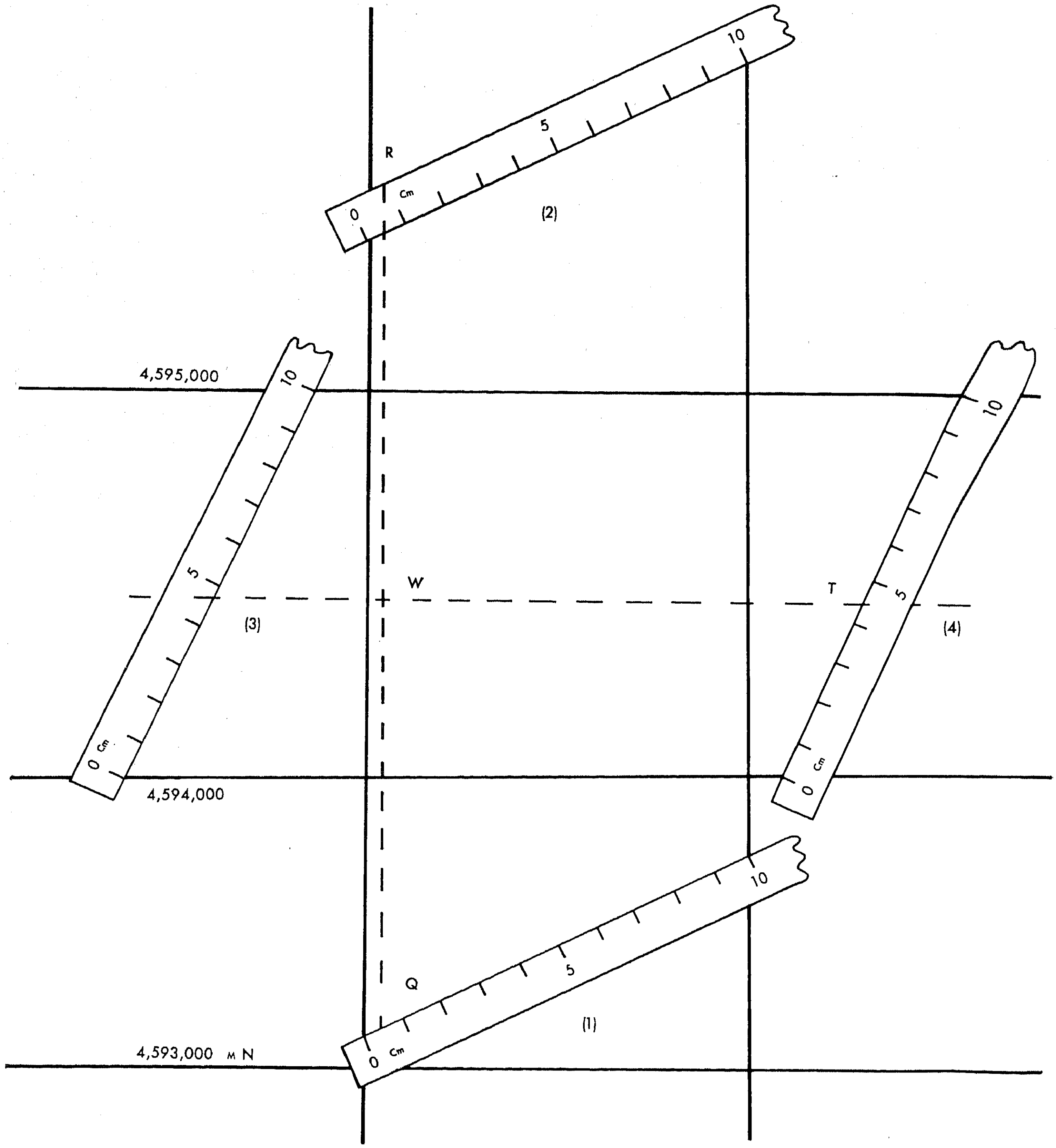


Figure 12. Grid square showing method of locating southwest geographic coordinate reference.

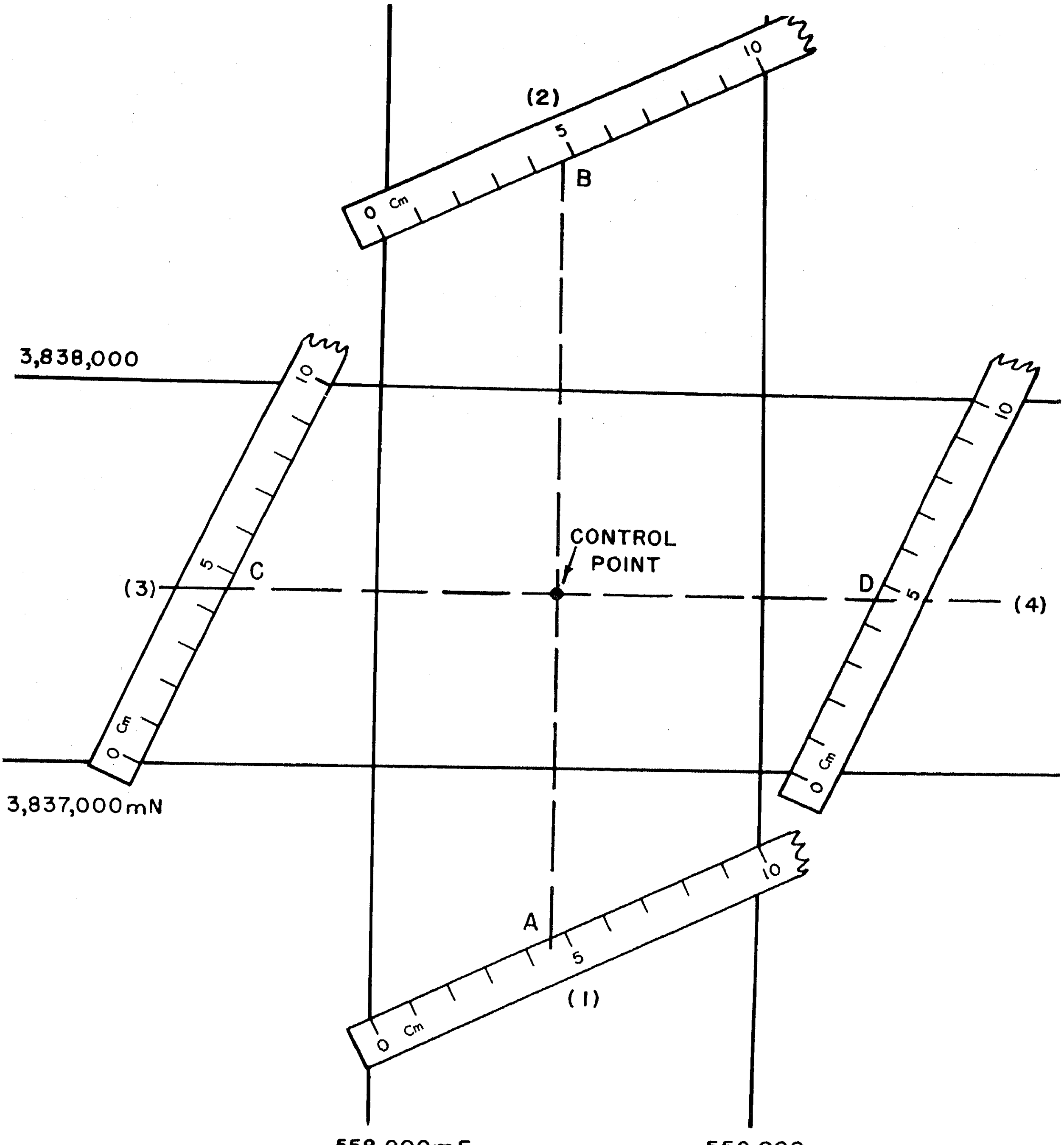


Figure 13. Plotting control with rectangular grid coordinates.

prick on the grid at Q. Repeat this operation at position (2) and mark R on the grid. The line drawn between Q and R is the easting coordinate 573,032m. To get the northing reading, place the scale at position (3) with the zero and the selected unit indicators on the horizontal grid lines, and pin prick 0.421 of the distance between the horizontal lines along the scale (point S). Move the scale to position (4) and locate point T. The line joining S and T represents the northing coordinate 4,594,421m. The intersection point W is the southwest corner of the sheet. The remaining corners are plotted in exactly the same manner.

26. Plotting Positions of Control Stations

a. Plotting Control by Rectangular Grid Coordinates. This method is similar to that employed for plotting the projection on the grid. After the rectangular coordinate or grid has been constructed and the lines numbered so that all the points to be shown fall within the numbered area, each station is plotted as follows:

(1) Compare the rectangular coordinates of the station given on the control data card with the numbered lines on the control sheet and select the proper square within which the station to be plotted will fall. For example, if a certain control point reads 3,837,470.00mN. and 558,470.00mE. on the control card, then the lower left corner of the full 1,000 meter grid square will read 558,000mE. for its vertical line and 3,837,000mN. for its horizontal line (fig. 13).

(2) Choose an appropriate graduation on the scale so that 10 units provide the distance between grid lines and lay the scale on the grid in position (1) so that the zero and tenth unit indicators straddle the grid lines. Measure along the scale to the calibration marking 0.470 of the distance between the vertical lines and mark a pin prick on the grid at A. Repeat for position B and connect A and B by a straight line.

(3) Place the scale in position C and lay off 0.470 of the distance between horizontal grid lines. Repeat for position D and connect points C and D with a straight line.

(4) At the intersection of the lines AB and CD, locate the control point.

(5) Mark and label the plotted station.

(6) Repeat the operations in (1) to (5) above until all stations are plotted.

(7) For a check, always compare the scale distance between the two last plotted stations with the known recorded or computed distance.

b. Plotting Control by Geographic Coordinates. Control points may be located and plotted using the geographic coordinates of the projection. When compilations are constructed with the one minute quadrangles drawn, the system as described in *a*(3) and (4) above can be used to plot the number of seconds for each control point. Each one minute quadrangle, which equals 60 seconds, can be divided into 60 divisions using a metric scale. On the scale, choose a value easily divisible by 60, such as 60 mm, 120 mm, 180 mm, or 240 mm, and capable of covering the distance between the minute lines. Each value of one second is then equal to 1, 2, 3, or 4 mm, respectively. The number of seconds multiplied by these factors total the number of divisions to be plotted.

CHAPTER 3

COMPILING

Section I. INTRODUCTION

27. Definition

Map compilation is the preparation of a new map, less final drafting and reproduction, from aerial photography, existing maps, charts, field surveys, intelligence data, and other source materials used either singly or in combination. The term map compilation means also the map drawing containing all information to be shown on the finished map ready for final drafting for reproduction.

28. Responsibility of the Compiler

a. A large part of the responsibility for preparing a satisfactory map, therefore, rests with the compiler, who must use extreme care in selecting map detail so that the finished map meets established standards of accuracy and also satisfies its intended purpose. The compilation must be clear and legible and include every item to be shown on the finished map, properly delineated and correctly positioned. Compilation which meets these requirements will simplify the task of the draftsman by eliminating any doubts which poor or improper presentation on the compilation might otherwise cause him.

b. The compiler should be generally familiar with all phases of cartography and allied subjects. He should have a thorough knowledge of map specifications and standards of map accuracy. Appendix I contains references dealing with military map specifications and standards of map accuracy. A good compiler will strive to expand his knowledge and to cultivate a capacity for independent thought and decision.

c. Any map is a graphic representation to scale of some part of the earth's surface plotted on a plane. It is impossible in compilation to map every feature on the earth in its true shape, orientation, or proportion. This is evident when one considers that on a map at the scale of 1:50,000, a square mile of the earth's surface must be condensed into a small square 1.27 by 1.27 inches. Any attempt to plot all features to scale would result in a map virtually impossible to read, and would require the use of a magnifying glass for recognition of the details. Furthermore, features are indicated by conventional signs and symbols to simplify drafting and must be exaggerated in size for legibility. At the reproduction scale of 1:50,000, using the prescribed symbols, a small house covers an area equivalent to about 85 feet square, and a road would be about 95 feet wide. Since all detail cannot be shown on a map, the compiler must use his judgment in deciding which items to leave out. The omission of unimportant detail adds to the value of a map instead of detracting from it because it permits easier identification of the more important features.

d. The problems of selection occur with features of secondary importance, and these should be selected on the basis of their *military* importance. When choice lies between several features, the one which would be most readily recognized in the field is preferable.

29. Steps in Map Construction

From the viewpoint of the map compiler, the making of a map consists of four major operations—planning, compiling, color separation, and map editing.

a. Planning. The first step, planning, involves the procurement of the source materials (pars. 11–17) for making the new map. Source materials include previous maps, suitable aerial photographs of the latest data available, compilation tracings from aerial photographs especially made for the new map, survey data, and intelligence data. The most reliable map or sketch of the area to be mapped is used as a planning diagram to which the source material is oriented. Overlays are prepared showing the coverage available, and what new coverage is to be obtained. When new photographs are necessary, specifications for the photography are

written and a flight line map is prepared to serve as a guide for the pilot. All new and old photographs are then indexed by use of either a flight index or a photo index (fig. 14).

b. Compiling. The second step is the task of the map compiler. The grid is constructed and the geographic projection (graticule) plotted on it. To this map base is added the necessary control data. Source material is then keyed to this control. The details of the map are compiled next. This may be done by plotting directly from a plane table sheet, or overlays prepared from single graphs. The detail may also be a from the photographs by the use c struments, such as the vertical (figs. 15 and 16), or by transferri ted separately, using the stereosc instruments.

c. Color Separation. The thir color separation drafting, which scribe-coated plastic sheets with

Figure 14. Photo index.

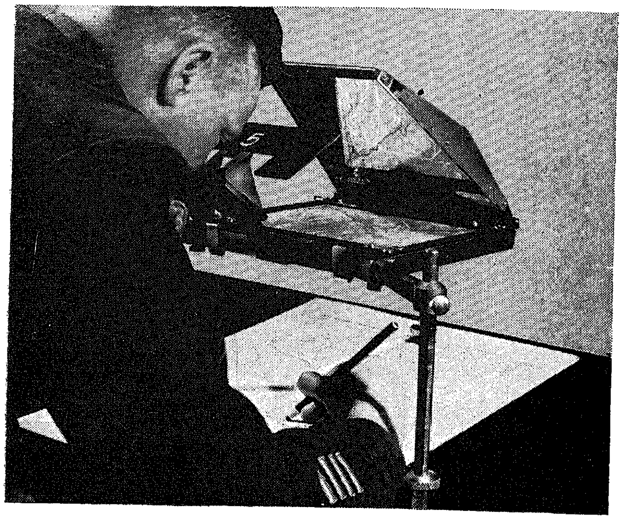


Figure 15. Vertical sketchmaster in operation.

sheet for each color that will appear on the final map. Blueline boards may be used alternatively.

d. Combination Map Compilation—Color Separation Methods. This system was developed primarily to eliminate the duplication inherent in the conventional system of preparing finalized compilation manuscripts, and then completely retracing the compiled features in preparing the color separation drawings. With the increasing trend toward scribing methods for the color separation phase of map production, this combination method became feasible when it became known that scribing techniques could be applied to the compilation phase.

(1) *Revised film positive method.*

(*a*) To make minor changes or additions of detail to the base source from aerial photography or supplementary sources other than symbol conversion, the compiler uses red plastic ink on the composite-positive mosaic of the base map source.

(*b*) When extensive changes are necessary, the appropriate compilation colors, as prescribed in the technical manuals on symbolization, are used.

(*c*) In either of the above cases, before inking the changes, make deletions by scraping the image from the emulsion of the mosaicked film positive. More complex local revisions can be worked out in pencil or ink on small acetate overlays. The overlay, or a film reduction of it, can then be backed by white opaque paper and taped (with transparent tape) into place over the mosaic. Detail appearing on the mosaic should not be deleted; it should be dropped at the compiler's discretion while performing the engraving of the color separation drawings.

(2) *Overlay method.* In this method, changes are made over the source material rather than on a mosaic of the source material. To use this method, the printed colors of the basic source must be photographically reproducible. If the source maps are reproducible, a sheet of transparent acetate is placed securely over the source map and the four corner geographic intersections are inked on the transparent overlay to maintain a visual keying position. Changes can be made on the overlay by blocking out undesired detail with white plastic ink and making additions and changes with ink of appropriate color and symbolizing added features. The source and the registered overlay can then be sent to the photographic laboratory for the processing of a scaled film positive. This film positive is one of the many to be paneled as part of the film positive mosaic from which color separation images on scribing plastic can be prepared directly.

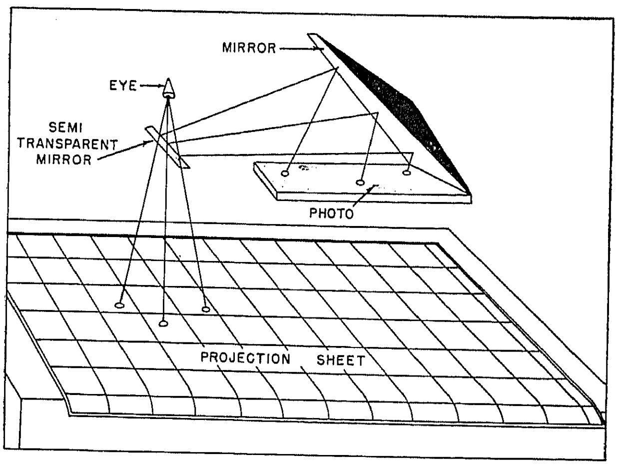


Figure 16. Optical principles of vertical sketchmaster.

(3) *Semidirect method.*

(*a*) Under (1) above, the revised film positive method indicated that more complex local changes were to be completely worked out on small acetate overlays to be backed with white opaque paper and taped in position over the film positive mosaic of the base source. In the semidirect method, to hold the revision time to a minimum, all aerial photography required for the changes is provided to the compiler in either scaled film negative or positive form so that the compiler may make the individual overlays in skeletonized form, which means major drainage or road nets are shown and matched with adjoining map detail. Later, the compiler can use the film prints of the aerial photography directly under the scribing plastic to fill in remaining detail.

(*b*) Also under this method, changes are not concentrated, but are numerous and scattered. As an alternative to the revised film positive method, all changes can be shown on an overlay keyed to the film positive mosaic rather than directly on the mosaic. The mosaic and keyed overlay can then be used to process a two-color image on each of the scribing plastics. The compiler can then scribe the base features from one color, and changes to the base features from the other color on each drawing as a result of a composite image. However, if the changes are all of one type (only culture, for example), then a two-color image needs only to be processed on one of the color separation scribing plastics rather than on all, unless features from some of the other drawings must be closely registered.

(4) *Direct method.* This method shows promise in achieving a truly combined compilation-color separation method. Here it is also assumed that the aerial photography is fairly distortion free and changes are numerous. After preparing the film positive mosaic, the compiler should prepare an overlay keyed to the mosaic on which he can cement scaled film or paper positives of the aerial photography, keyed to the manuscript through common detail, especially areas requiring changing. The mosaic and keyed overlay can then be used to process a two-color image on the scribing plastic, but the image of the photography can be either a halftone or a continuous-tone image, depending on the desired density. In either case, the compiler can scribe the base features or changes directly from the photography.

(5) *Distorted photography.* In the information above, emphasis is on undistorted aerial photography. If photography is distorted, it will require an extra step of rectifying the distortion by pull-ups or tracings of individual prints using the reflecting projector and adjusting to the base source or supplemental map source. It is only the vegetation overlay that can be adopted for preparation under the combination compilation-color separation method outlined in (1) through (4) above. Other overlays (names or road classification) must be prepared under conventional compilation methods.

(6) *Compilation edit.* For a compilation edit, make an ozalid copy of the film positive mosaic. Where changes have been made separately, make an ozalid copy of the change overlays.

e. Editing.

(1) *Compilation edit.* This is the first formal edit done by the battalion edit section, and it is made when the final compilation is completed. With the compilation manuscript, the map source data, and the map preparation instructions, the editor reviews the work to see if it meets the specifications and instructions. Errors may be indicated by marking symbols on an overlay on the compilation manuscript.

(2) *Drafting edit.* After the color separation sheets have been inked, a drafting edit is performed to insure that color separation material agrees with the final compilation. A set of composite monochrome proofs can be used as a correction copy. Errors are noted and the material is returned to drafting for correction. If there are no errors, the blueline boards or scribed plates are forwarded to the reproduction company for the preparation of proofrun copies.

(3) *Edit of proof.* The next step is proofrun. Proof press reproduction requires the preparation of press plates and negatives if blueline boards are received. Usually only three or four copies in full color are run off for proof edit, which is the last complete edit before press run and distribution. This consists of a detailed check of the proofrun for errors in registration, symbol colors and color separation, coloring, placement of marginal data, major errors, and similar items.

(4) *Second edits.* All corrected material should be reedited to insure that the corrections called for have been made. When possible, the second edit should be performed by an editor other than the one who made the first edit.

30. Materials

a. Source materials for map compiling are described in paragraphs 11 through 17. The extent to which source material is used depends upon the method of compilation. When original plane table or photogrammetric work is used as source material, source maps are strictly of a supplementary or interpretive nature.

b. Compilation materials also depend upon the method used. Normally, the compilation materials consist of—

(1) Photographs.
(2) Field classification data.
(3) Original maps.
(4) Multiplex templets or manuscripts.
(5) Scribed negatives or blueline boards.
(6) Photo positives or negatives.
(7) Monochrome manuscript.

Section II. PRINCIPLES OF COMPILING

31. Compiling

a. Plotting. All compilation, as far as possible, will be a true representation of terrain detail. The center and orientation of a symbol will normally correspond with the center and orientation of the feature represented. All line features, such as roads, railroads, powerlines, and streams will be plotted in their true positions and will retain, wherever scale permits, the variations of alinement which actually exist. The compiler must take care in plotting these features, since the draftsman will copy them just as they appear on the final compilation. Important roads, railroads, streams, levees, and like features lying parallel and close to each other may require an exception to the rule. An exaggeration of the area covered may be necessary to show these features by their proper symbols. The displacement should be distributed evenly, with the true center of the parallel features—taken collectively—held wherever possible and with the contours adjusted to the symbols. When it is impossible to plot or identify a feature on the compilation because of inadequate source material or the minuteness of character of the feature on aerial photographs, the questionable item should be noted on a print of the compilation for investigation by the field check party.

b. Matching Compilation Sheets. Every effort will be made to match the new compilation with existing adjoining sheets of the same scale or with adjoining compilations made for the same scale which are known to meet the standards of accuracy. In attempting to match borders, however, no errors will be introduced into the new compilation that exceed the permissible limits of accuracy, nor will any factual errors be made in an attempt to tie to existing adjoining sheets. The latter may be in error or out of date.

32. Accuracy

Military maps will normally be prepared in accordance with the following accuracy requirements. However, where source materials,

weather restrictions or aerial photography, or other factors do not permit meeting these requirements, maps of lower accuracy standards will be prepared.

a. Horizontal Accuracy. For maps at publication scales smaller than 1:20,000, 90 percent of all well-defined features, with the exception of those unavoidably displaced by exaggerated symbolization, will be located within two one-hundredths of an inch (.02 inch) at publication scale, of their geographical positions as referred to the map projection.

b. Vertical Accuracy. Ninety percent of all contours and elevations interpolated from contours will be accurate within one-half of the basic contour interval. Discrepancies in the accuracy of contours and elevations beyond this tolerance may be decreased by assuming a horizontal displacement within the tolerance specified above. Elevation values of 90 percent of all spot heights shall be accurate within one-quarter of the basic contour interval.

33. Scales of Compilation

When compiling by photogrammetric methods, the scales of individual compilation sheets are often determined by the scale of the photography and the limitations of the stereoplotting equipment. When individual sheets of different scale have been compiled, film positives are made at the scale of the final compilation base and mosaicked together. The final compilation manuscript obtained by photogrammetric or stereophotogrammetric methods may be prepared for reproduction at one-fifth reduction or at reproduction scale (1:1), depending upon the color separation technique utilized.

34. Symbolization on Compilations

a. On working compilations, symbols may appear in black pencil, and strict adherence to the lineweights indicated will not be required. When the working compilation is made at scales larger or smaller than the drafting scale, proportionate changes in measurements will be made in order that symbols which appear on final drafting media may approximate the drafting scale.

b. Generally, symbols on compilations will appear in their respective colors, unless otherwise directed. In the final map, topographic symbols usually appear in the following colors: black for cultural (manmade) features; blue for water features; brown or gray for relief features; green for vegetation; and red for road classifications.

35. Final Compilation

a. Composition. Each sheet of the map requires a final compilation which may be prepared in several ways, including: (1) mosaicking, then inking the compilation manuscript on metal-mounted paper or on stable plastics with plastic inks; or (2) using the process of compilation color separation employing engraving (scribing) techniques, which include the possibility to compile and engrave in one operation. The scale of the compilation will be determined by the chief of the compiling unit, since it will depend on the source material and the methods employed. Normally, the final compilation will consist of the base compilation, names, woodland, and road classification. For certain revision methods, only the base compilation and the woodland are required.

b. Compilation Details. The details of compilation are specified by mapping instructions. The publication scale determines the amount and type of details that will be included. The final compilation must be complete, for it serves not only as a base for the color separation images, but also constitutes the sole reference for the draftsman and reviewer.

36. Form Lining

In military operations, it is often necessary to show relief of an area without time or means to obtain vertical control. This is done by sketching form lines on the photographs or on transparent overlays. Form lines do not represent any order of vertical accuracy, but they afford a means of showing up and down grades as well as high and low features in the area. Form lines are plotted similarly to contours, but the controlling elevations are assumptions based on logical interpretation of the terrain. Primarily, a careful study of the terrain is made, noting especially the drainage system. Then, based on the most intelligent conclusions, definite assumed elevations are assigned to maximum and minimum elevations in the area. Based on these, definite elevations are assigned to all critical points, such as ridge tops, stream intersections, and sudden changes in slopes.

With this assumed control network, form lines may be sketched between control points, using a stereoscope. When one or two ground control points are available, they may be used as a basis upon which the control network for form line sketching is assumed.

37. Logical Contouring

a. Background. Logical contouring is a procedure which permits the sketching of contours from field notes with considerable accuracy and without the need of running a level line for every contour. Whenever possible, contouring should be accomplished in the field directly on the plane table sheet, but it is both possible and permissible to add contours to a field sheet after the surveyor has completed his work. The basis of logical contouring is the fact that contours are spaced equally along a uniform slope. This fact is put to use by having the surveyor furnish a spot elevation at every point where there is a change in slope. Since every change in slope is indicated by a spot elevation, it follows that the slope between spot elevations is uniform, and one may therefore interpolate contours with accuracy by spacing them proportionately between the given elevations.

b. Method. Logical contouring should be approached systematically, and for best results may be divided into the following five steps:

(1) Determine the elevation of all stream junctions.
(2) Locate the points where contours cross the streams.
(3) Sketch in the ridgelines.
(4) Locate the points where contours cross the ridges.
(5) Draw the contours by connecting points of equal elevation.

c. Illustration. In the illustrative problem which follows, the procedure above is used to add contours at 20-foot intervals to a simulated plane table sheet (fig. 17) which contains a drainage pattern and scattered spot elevations.

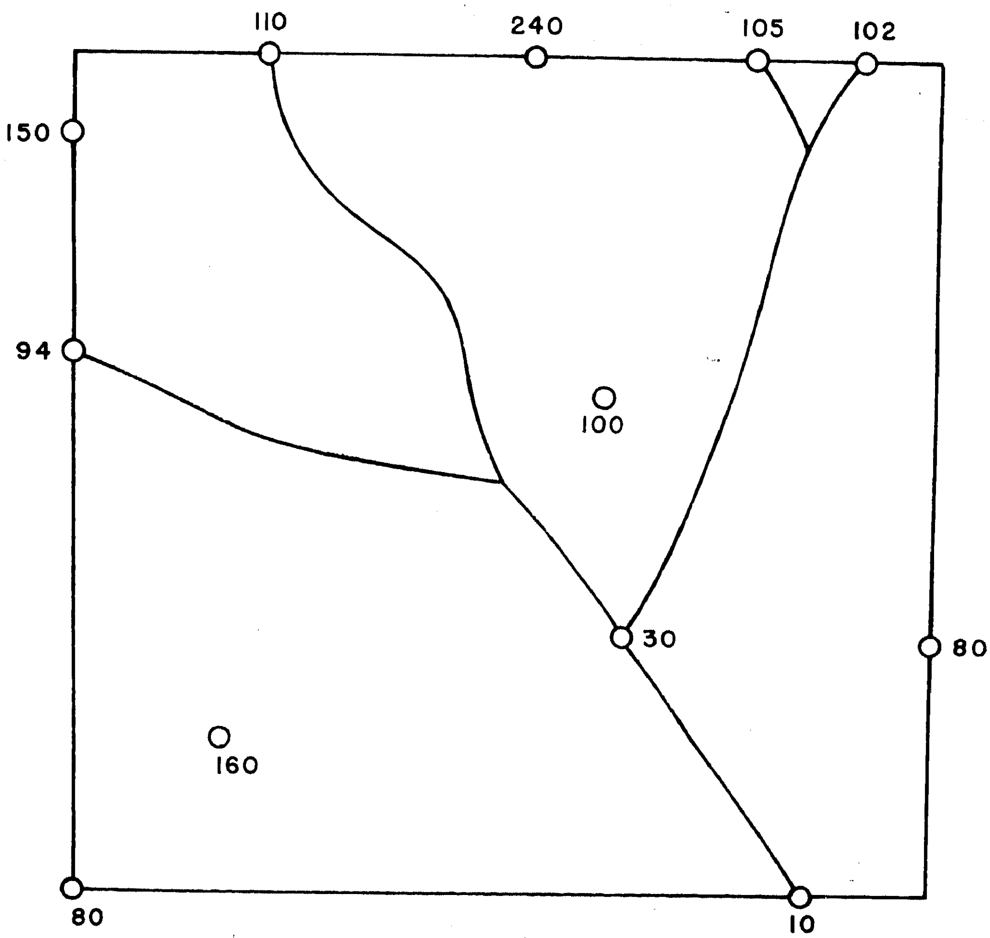


Figure 17. Logical contouring—plane table sheet.

(1) The first step is to determine the elevations of all the stream junctions (fig. 18).

(2) The next step is to locate the points where contours cross the streams (fig. 19). In indicating the points where the contours cross the stream, use the characteristic V-shaped mark.

(3) The next step is to sketch in the ridgelines (fig. 20). Streams are always separated by higher ground between them. If there were no higher ground to separate the streams, they would flow together, forming a swamp or lake. A ridgeline will, therefore, run between two streams and down into the stream junctions.

(4) Additional lines may be drawn between the spot elevations falling between streams and other points of known elevation as shown by the lines radiating from the spot elevation 160 in figure 21. Take care, however, that these lines do not cross either each other or a stream.

(5) The points where contours cross the ridges are determined in the same way as the locations where contours cross the streams (fig. 22).

(6) Since, by definition, a contour is a line connecting points of equal elevation, all that is necessary to draw the contours is to connect the points previously plotted. The method of drawing contour lines is shown in figure 23.

(7) Index contours are accentuated, guide lines and unnecessary elevations removed, and contour lines numbered (fig. 24). The job is then complete. From only a drainage pattern and some scattered spot elevations there has been developed a contoured sheet

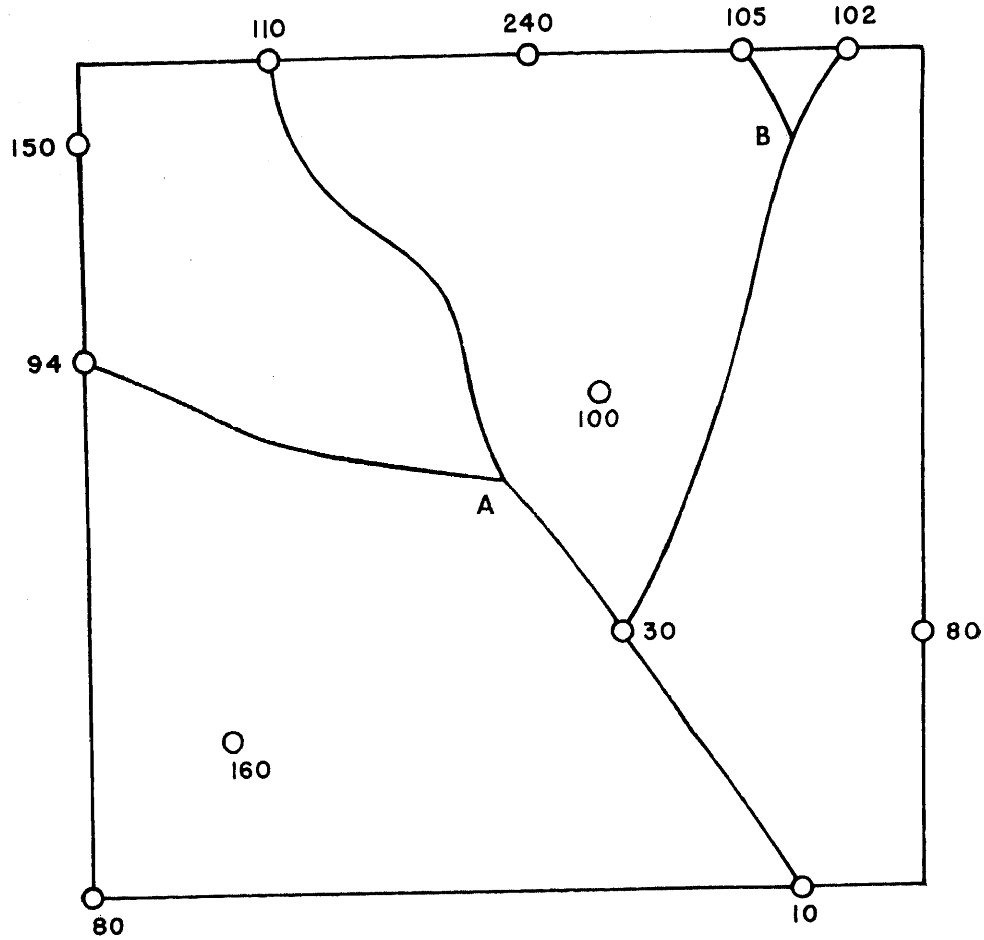


Figure 18. Logical contouring—elevation of stream junctions.

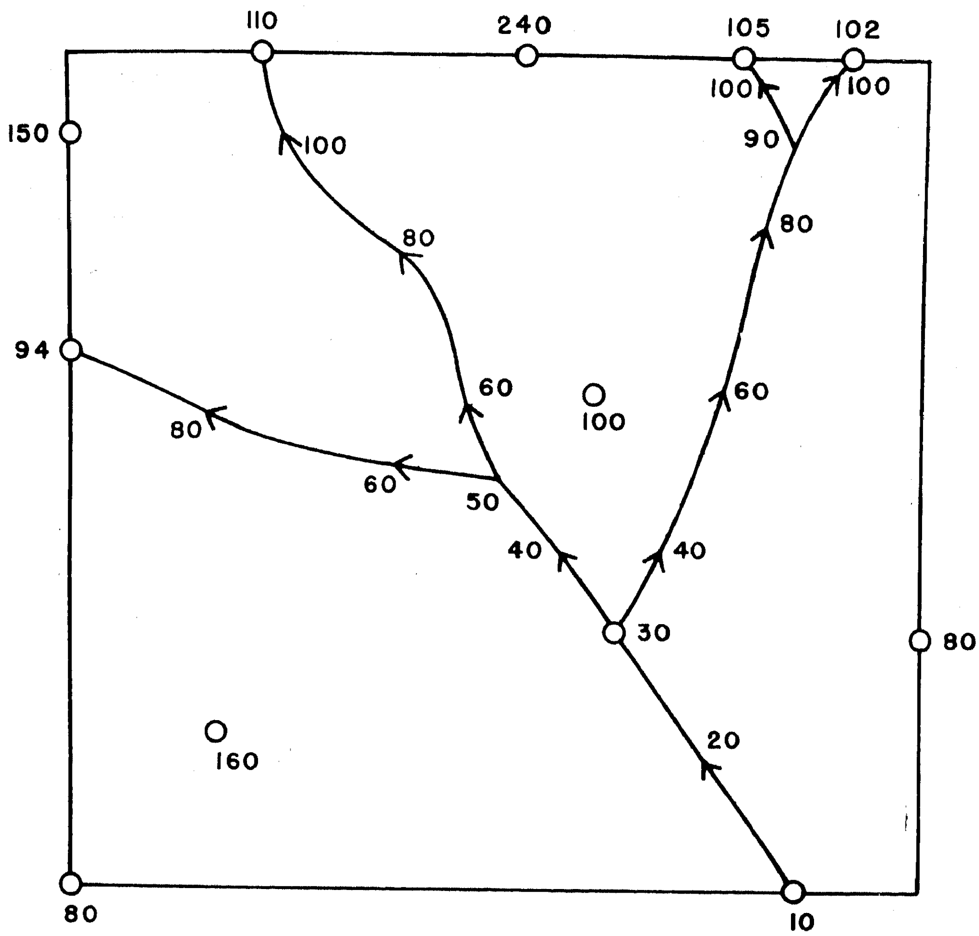


Figure 19. Logical contouring—locating points where contours cross streams.

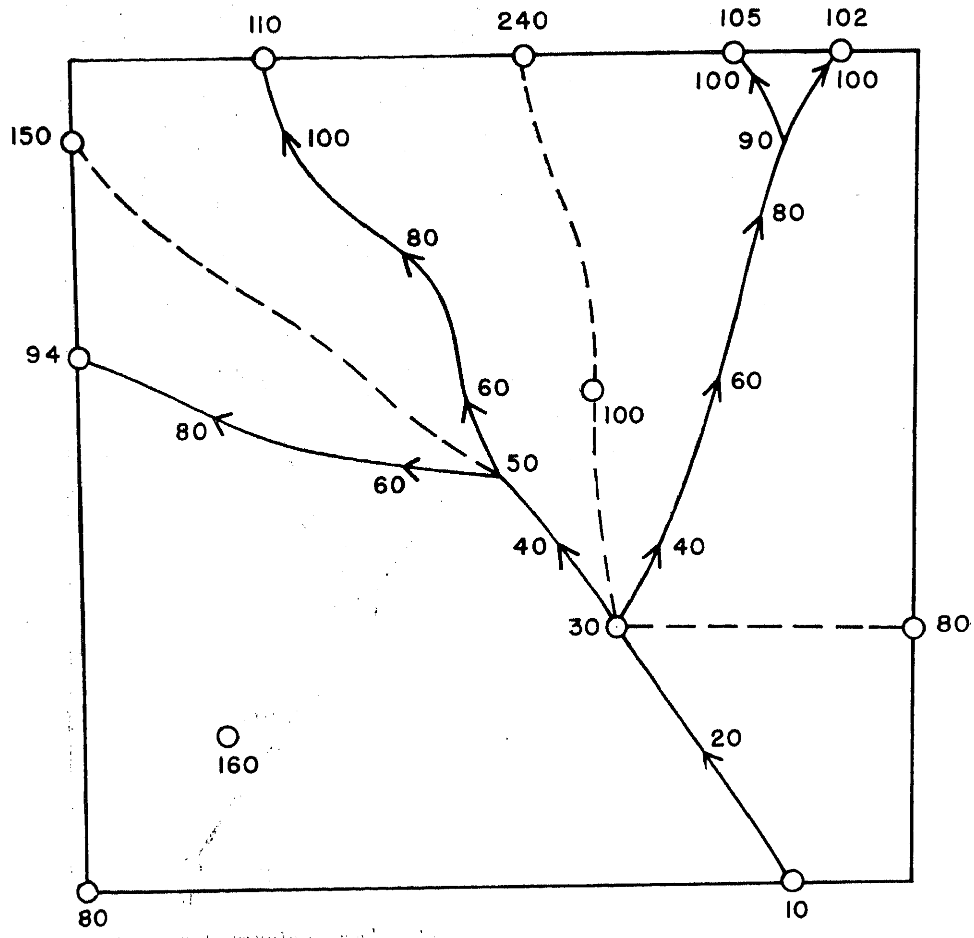


Figure 20. Logical contouring—sketching ridgelines between streams.

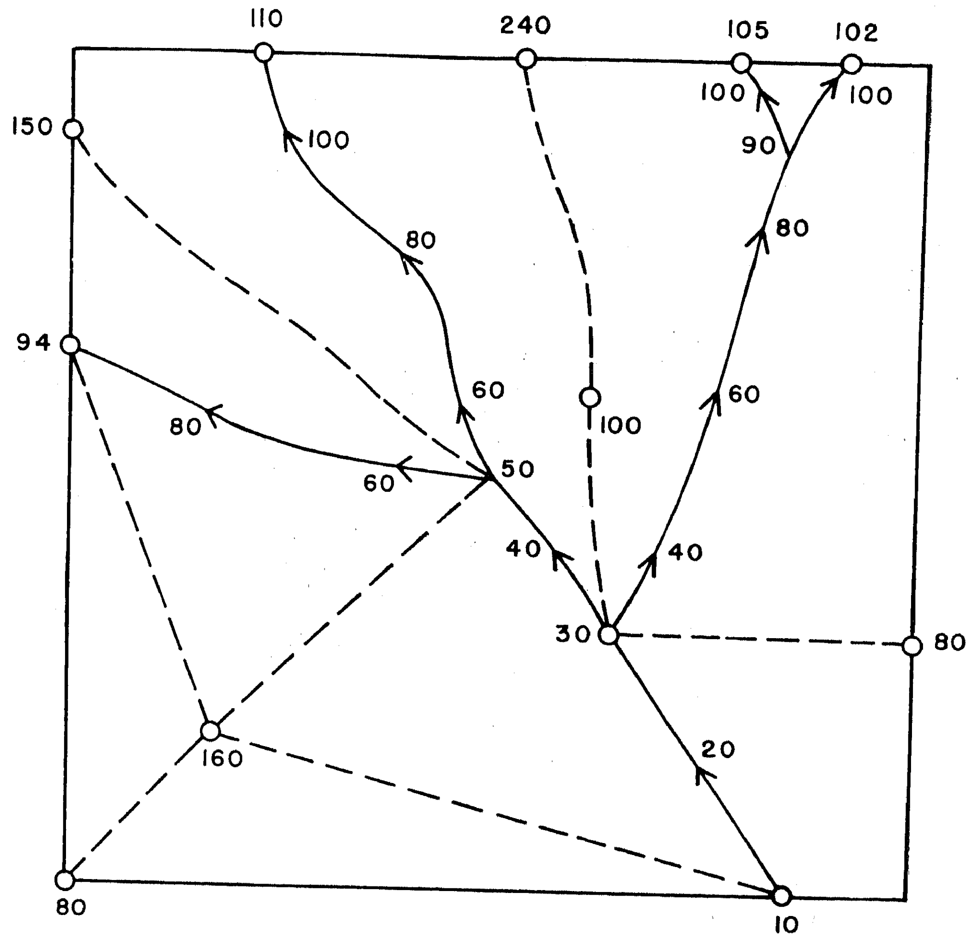


Figure 21. Logical contouring—sketching ridgelines to spot elevations.

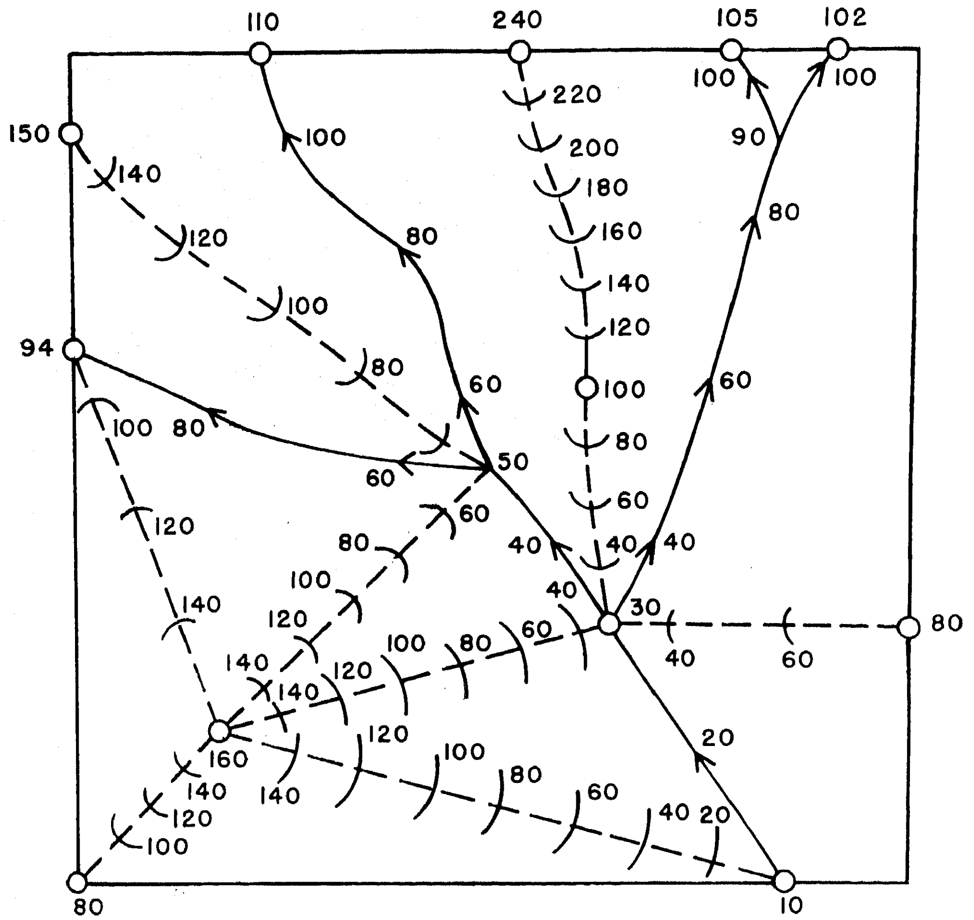


Figure 22. Logical contouring—locating points where contours cross ridges.

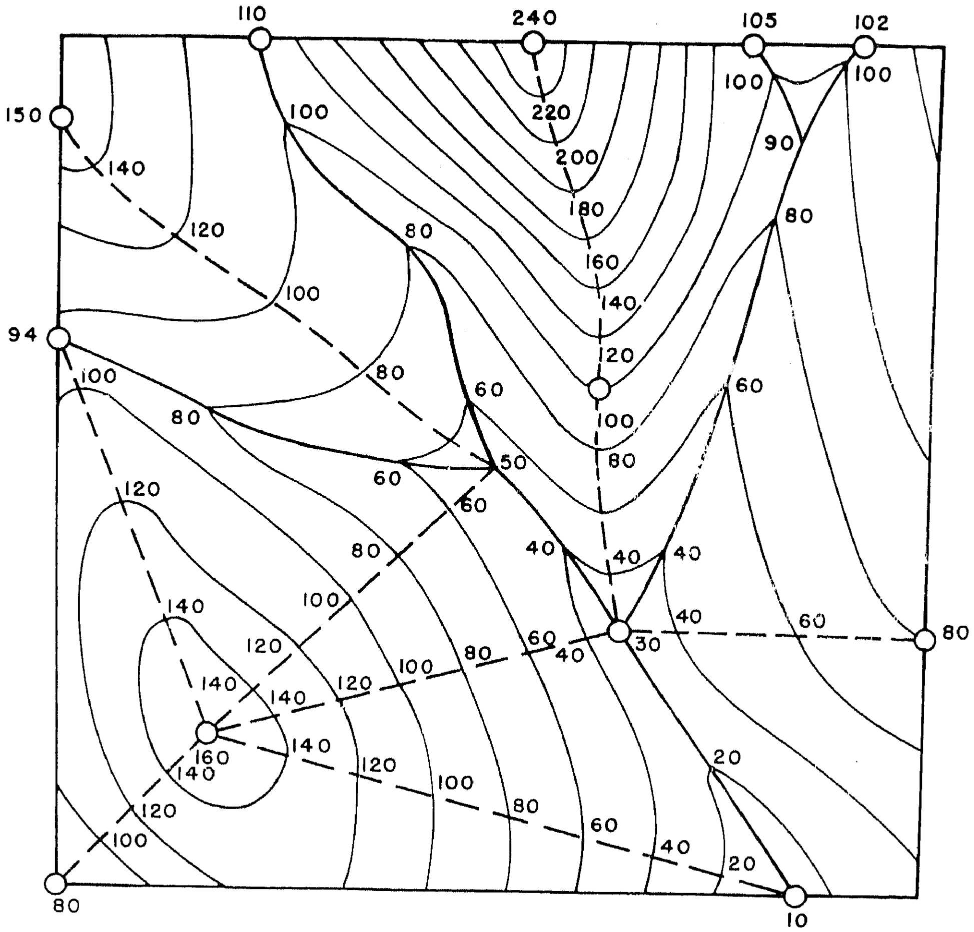


Figure 23. Logical contouring—drawing contours.

on which the elevation of any point may be readily determined.

d. Characteristics of Contours.

(1) Contours are smooth curves.

(2) Contours never cross or touch except at overhanging or vertical cliffs and at waterfalls.

(3) Contours are approximately V-shaped in narrow valleys, with the V pointing upstream; are generally shaped as U's pointing down ridges, and are shaped as an M just above stream junctions.

(4) Contours tend to parallel streams and to parallel each other. This reflects the fact that changes in ground form are usually gradual.

(5) Contours never fork.

(6) Every contour closes on itself, either within or outside the limits of the map.

38. Other Methods of Indicating Relief

a. Hachures. The hachure method of representing relief is often used when relief data are inadequate to draw contours, and is frequently found on foreign maps. Hachures are short parallel or slightly divergent lines drawn in the direction of slopes. They are closely spaced on steep slopes, wide apart on gentle slopes, and converge toward the tops of ridges and hills (fig. 25).

b. Gradient Tints. Another method of depicting relief is by the gradient tint system. Different colors or different tones of the same color show different zones of elevation. Each zone is bounded by contours, usually shown on the map; contours within the zones are sometimes shown. The map margin carries a key showing the elevation of zones according to color.

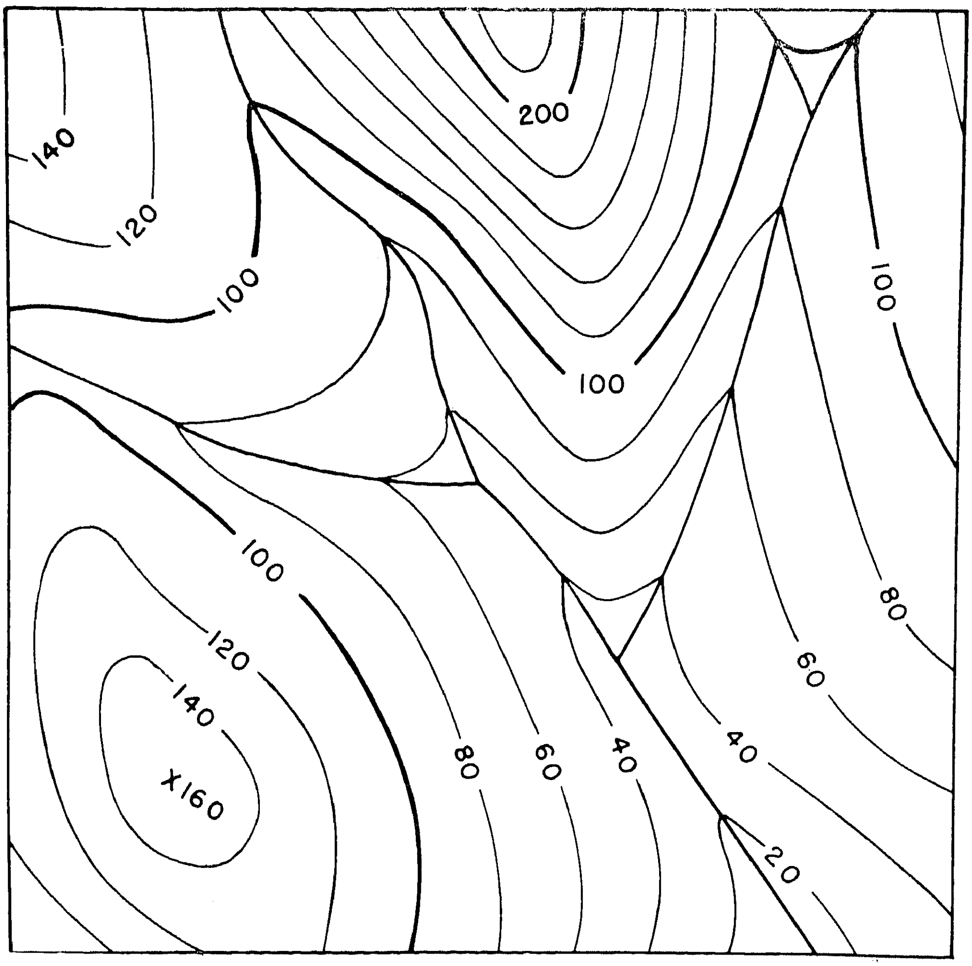


Figure 24. Logical contouring—indexing.

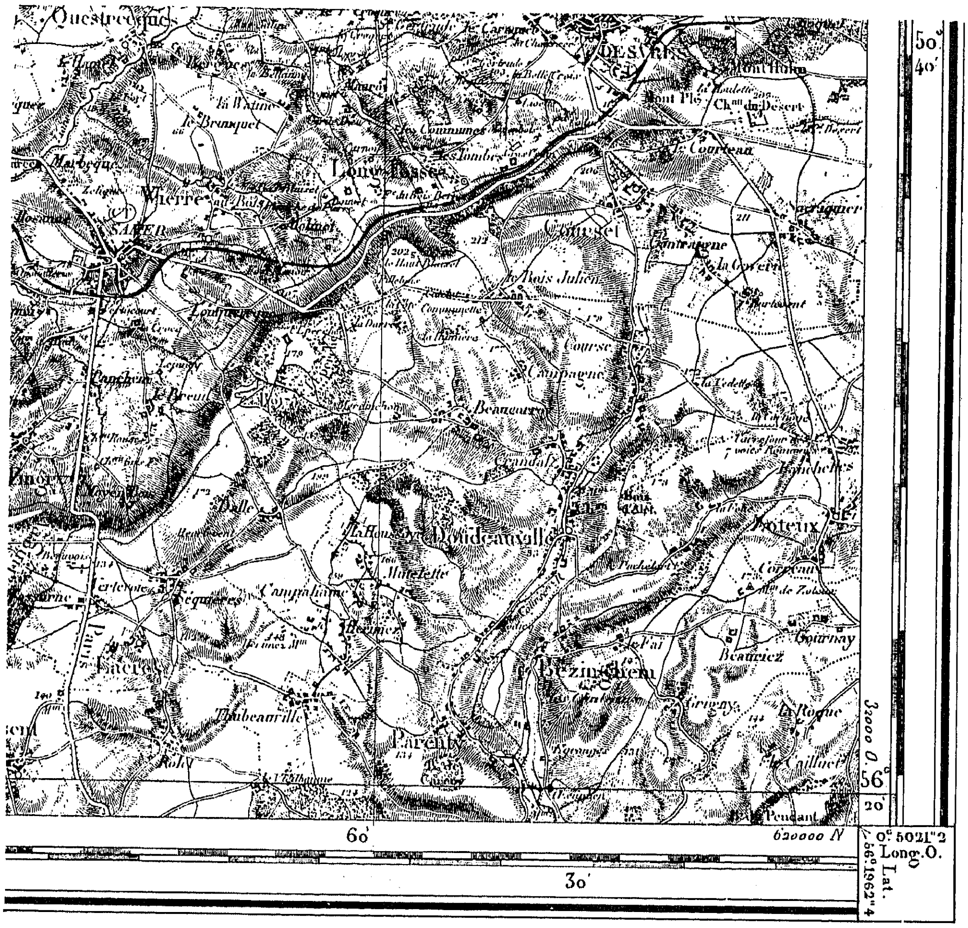


Figure 25. Illustration of part of a hachure map.

c. Shaded Relief. The shaded relief method of relief representation is generally used to supplement contour lines (fig. 26). It permits a ready interpretation of the general form of the terrain. Relief is shown by a light and shadow effect which would be obtained if a light shone upon the relief from the northwest. The shaded relief drawing is ordinarily accomplished with crayon or air-brush and printed on the map as a half-tone in the contour line color.

d. Plastic Relief Maps. During World War II, three-dimensional relief maps, wherever they existed, were used to great advantage for all types of military operations. This was especially true where it was imperative that ground information be presented clearly in a minimum of time. Early relief maps were made of plaster or sponge rubber, but the more recent search for a lightweight relief map that could be economically manufactured in great quantities led to the development of a technique of making plastic relief maps. In this technique, normal map color plates are printed on plastic sheets by offset lithography. These flat plastic map sheets are then deformed by heat and vacuum over a plaster mold of the modeled land forms of the area. The cost of each completed plastic relief map is very small compared to the cost of a plaster or sponge-rubber relief map. Again, mass production is feasible, for once the master mold is made, it takes very little time to form the plastic relief map. The new product is light in weight and lends itself to easy shipment—a large number can be shipped in a single package, since the maps naturally nest into one another. Figure 27 shows a plastic relief map.

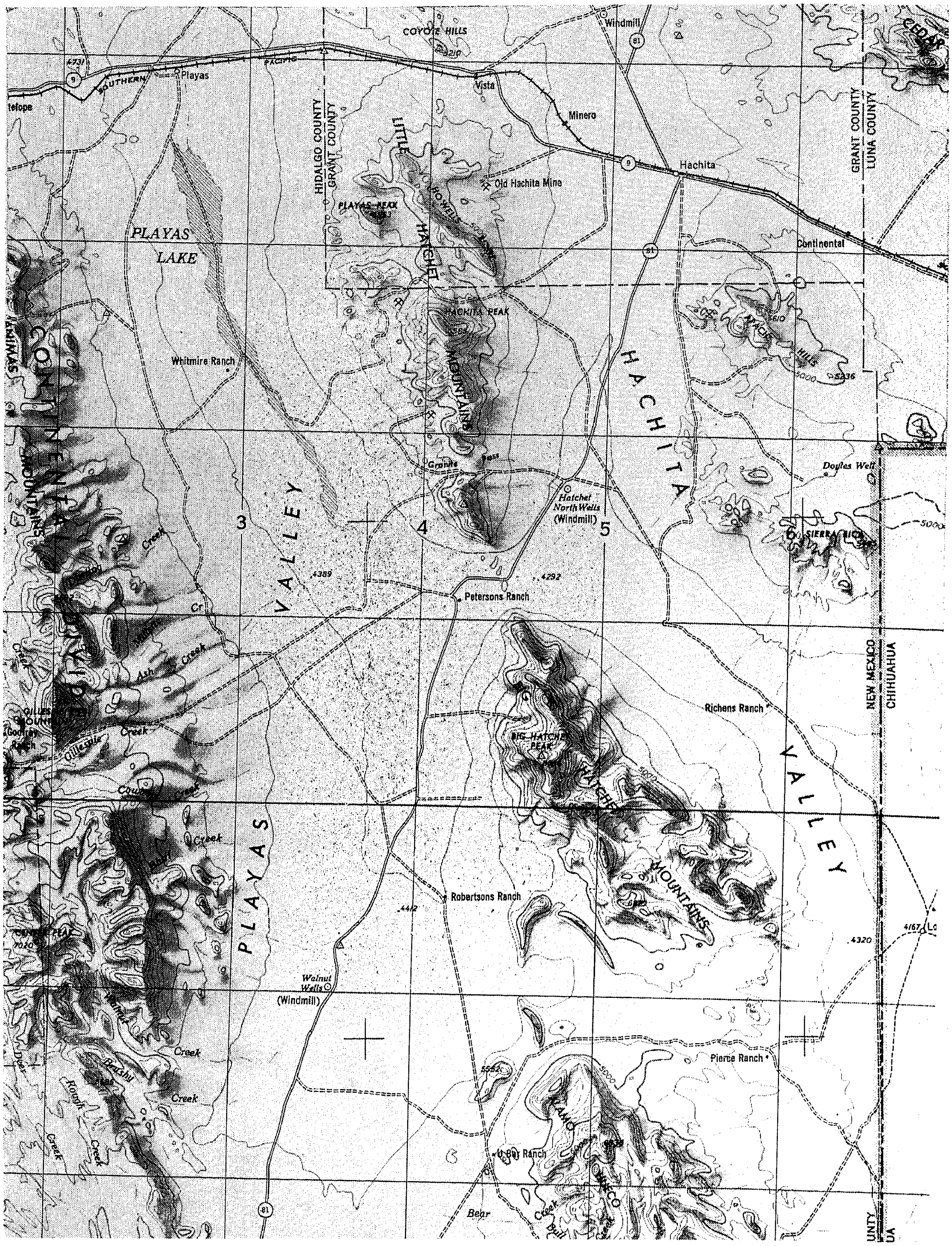


Figure 26. Illustration of part of a shaded relief map.

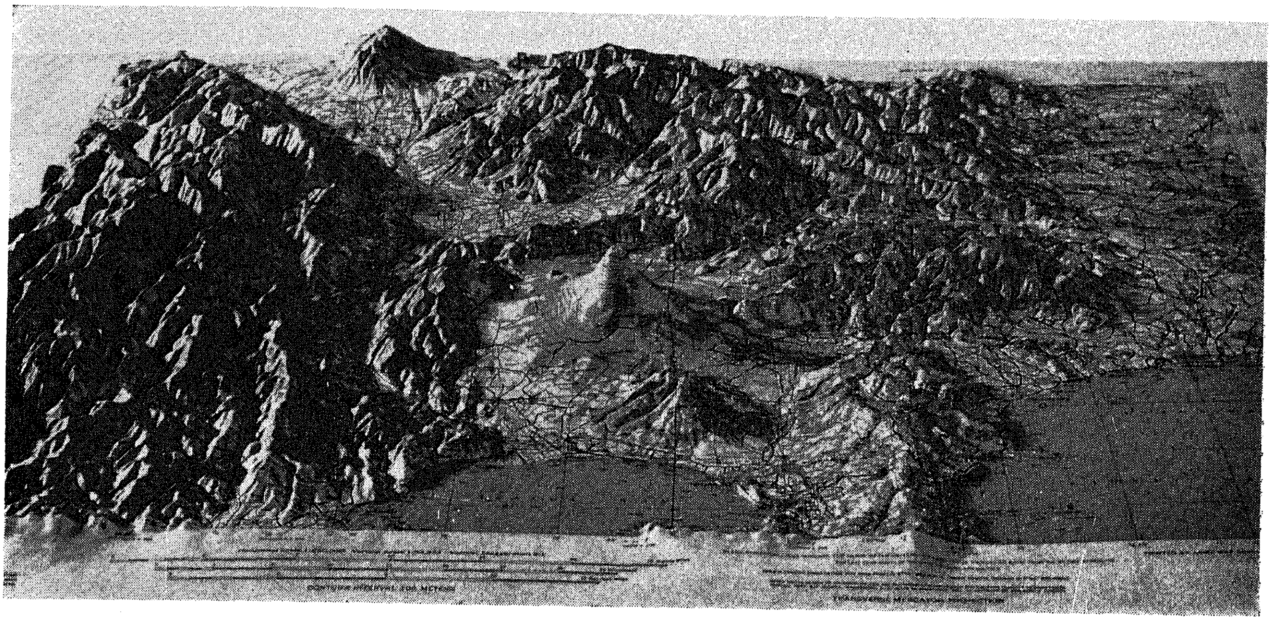


Figure 27. Plastic relief map.

Section III. COMPILATION INSTRUMENTS AND PROCEDURES

39. Aerial Photographs

a. Introduction. The single factor that did most to revolutionize the science of cartography was the advent of aerial photography. The aerial photograph furnishes, more completely than any other means, the information needed to prepare a map. The vertical aerial photograph approaches the ideal for mapping purposes because it registers all objects and features, not obscured or screened, in their proper perspective relation to one another. In areas free from trees and structures, a good vertical photograph will provide the compiler with practically 100 percent of all the features required for mapping. Only the invisible items, such as political boundaries, names, and underground features will not be apparent. This is also true for features that are obscured by woods, bluffs, and manmade structures.

b. Use of Aerial Photographs in Compiling. At standard mapping scales, any small portion of a map is considered to be an orthographic projection. The first task facing the compiler is to convert the photograph image from its perspective projection to a suitable orthographic projection. Methods for doing this are described in paragraphs 81 through 88. The second task is obtaining, from the aerial photograph, sufficient, accurately located points to provide for bringing together into proper relationship the details that will make up the body of the map. Control methods for doing this are described in chapter 7. Third, there is the difficulty of extracting the mass of detail from the aerial photograph and transferring it to the map. Methods for doing this involve the interpretation of the planimetric features on the photograph.

40. Restitution

a. Considerations. Restitution is the determination of the true (map) position of objects or points, the image of which appears distorted or displaced on aerial photographs. Good vertical photographs of terrain of small relief approximate the characteristics of a map. However, it is desirable that the draftsman be able to use, either in conjunction with maps or as substitutes for maps, photographs which contain tilt or obliquity and relief. He must be able to plot the map positions of images recorded on such photographs and know how to transform the detail from the oblique to the horizontal when this is necessary for correcting existing maps or constructing new ones. Some graphical methods of restitution are described in *b* through *g* below. Most methods described restore the incorrect position of points to their

correct or nearly correct photographic position, correcting for displacement of tilt only. The radial line method is the only method which makes corrections of displacements due to both tilt and relief when the tilt is less than 3° and the relief is not extreme. Photographic methods of rectification are discussed in paragraph 91.

b. Location of Points by Strip Method. This method may be used to determine the map location of a few points on an aerial photograph. It may be employed with both tilted and oblique photographs. It will not eliminate the effect of displacements of position caused by relief. It is especially useful in bringing maps up to date by locating on them features which did not exist at the time the map was made. It is not necessary that the map and photograph be of the same scale. Assume that it is desired to determine the map location of X and Y, respectively, on an aerial photograph (fig. 28).

(1) Select as control, 4 points readily identifiable on both the photo and the map (A, B, C, D) and join them by lines as shown. In general, the points to be located should be within or near this quadrilateral.

(2) Draw the diagonals AC and BD.

(3) From any two of the 4 control points on the photograph, as A and C, draw rays through the points X and Y. Select the ray centers to give good intersections at the desired points.

(4) Place a paper strip as in 1, figure 28, and mark on the paper strip e, f, and g (points where the lines of the figure cross the strip) and x and y where the rays to X and Y, respectively, cross it.

(5) Place the paper strip as in 2, figure 28, so that e, f, and g fall on their respective lines from A, and mark on the map points x and y as determined by the marks on the paper strip.

(6) Draw rays on the map from A through X and Y.

(7) Similarly, place another strip on the reverse side of the paper over the photograph as in 3, figure 28, marking the position of the 5 rays from C.

(8) Place the second strip on the map, mark on the map as in 4, figure 28, points x′ and y′, and draw the rays Cx′ and Cy′. The intersections X′ and Y′ give the locations on the map of the points X and Y on the photographs.

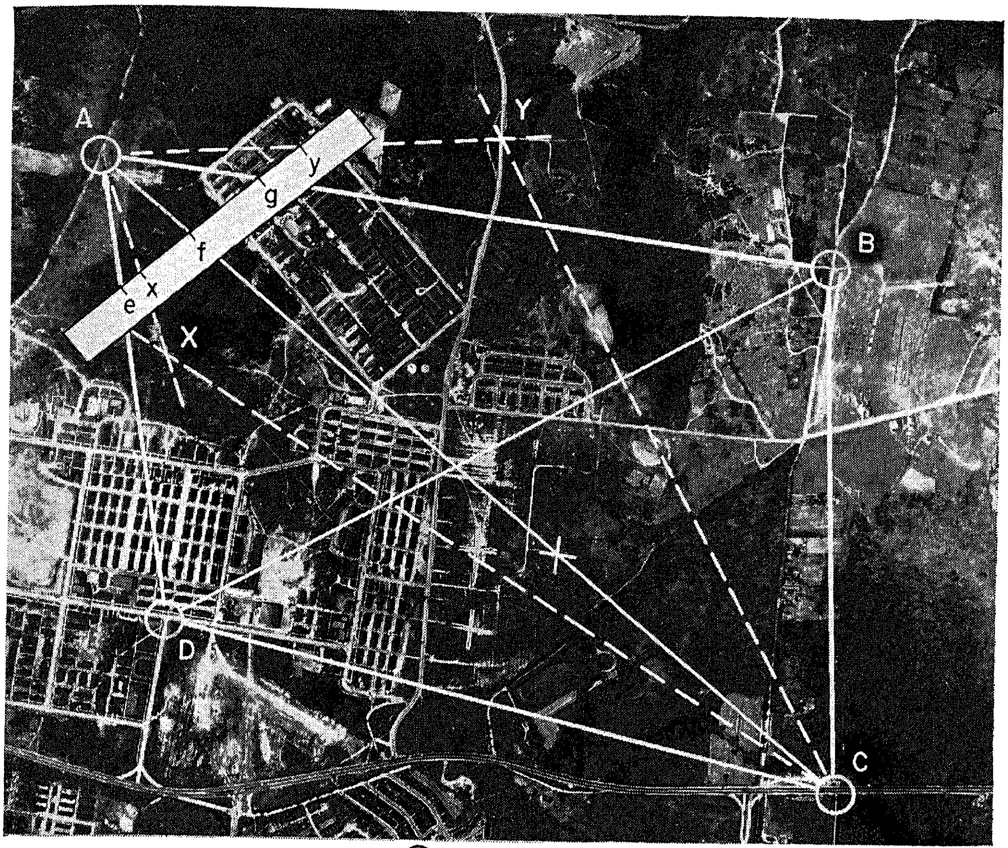
c. Location of a Point by Tracing Paper Method of Resection. This method may be used to plot roughly the map position of a limited number of points appearing on a vertical photograph.

(1) Identify on the photo at least 3 points (preferably 5) that appear on the map (fig. 29). Mark on a sheet of tracing paper the position of these points and of the point to be located on the map. This is done most readily by tacking the photograph over the tracing paper and pin-pricking through each point.

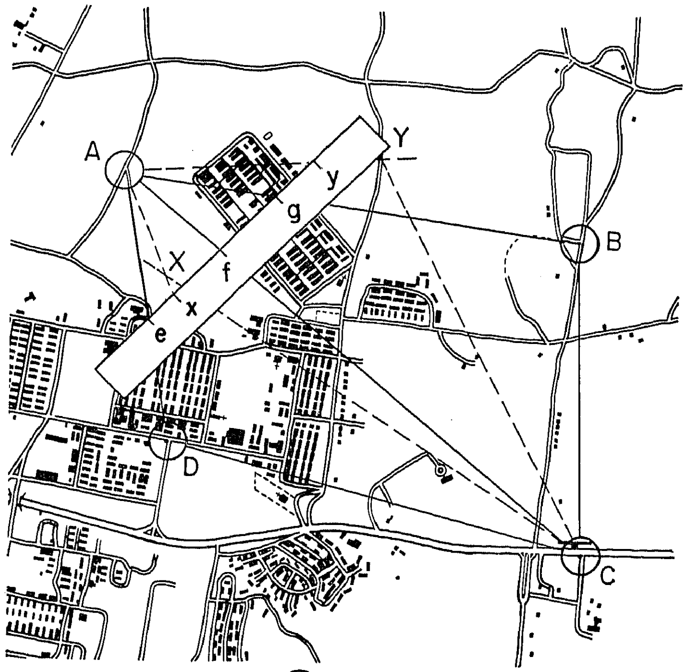
(2) Draw rays on the tracing paper from the point P, the location of which is desired, to each of the known points as a, b, c, d, and e. Place the tracing paper on the map so that the ray to each of the known points passes through the map location of the corresponding point. The point to be located is then in its relative position to the known points, and may be pricked onto the map.

(3) This method cannot be properly termed restitution because errors of tilt and relief in the photograph are in no way corrected unless the point, the location of which is desired, chances to fall, in their respective cases, either on the isocenter or the plumb point of the photograph. However, the error of location can sometimes be reduced by selecting more than the minimum of 3 known points. Thus 5 known points may be selected, and it may not be possible to cause all 5 rays to pass through the respective map positions at one time. If 4 can be made to do so, the other ray may be deemed in error and disregarded.

d. Location of a Point by Radial Line Method. The principles of radial line plotting are based on the assumption that all the photographs involved are truly vertical. Relief displacement, radial lens distortion, and differ-

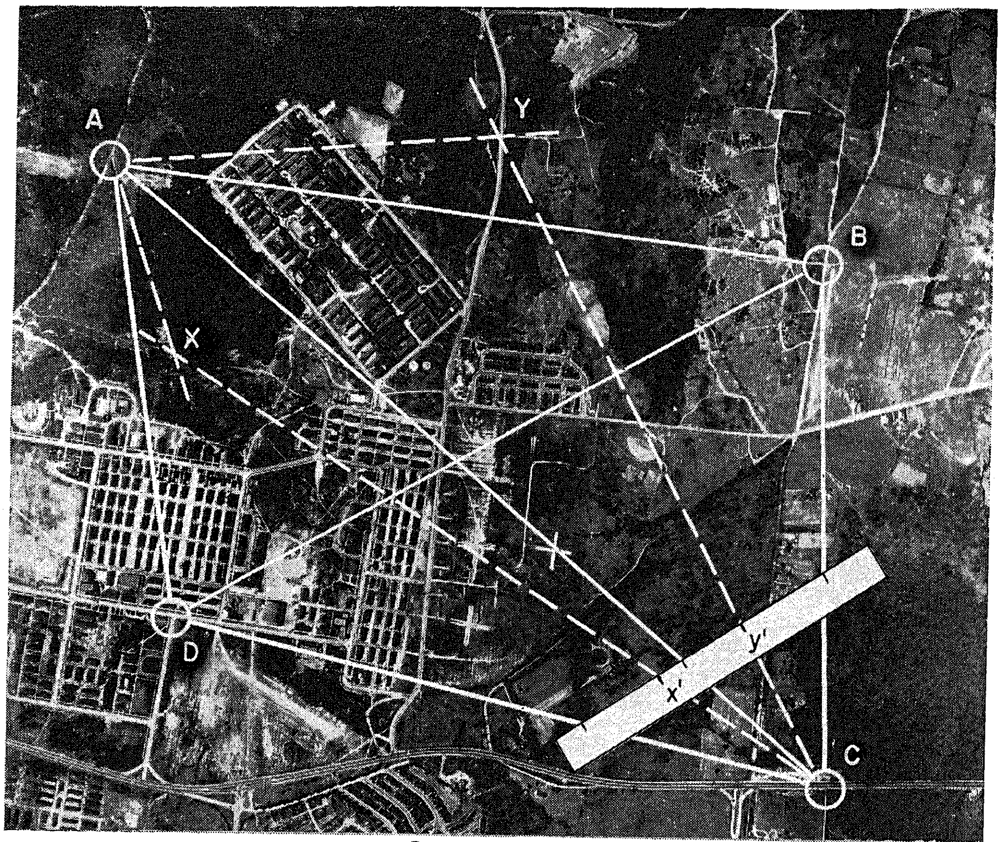


(1) Photograph

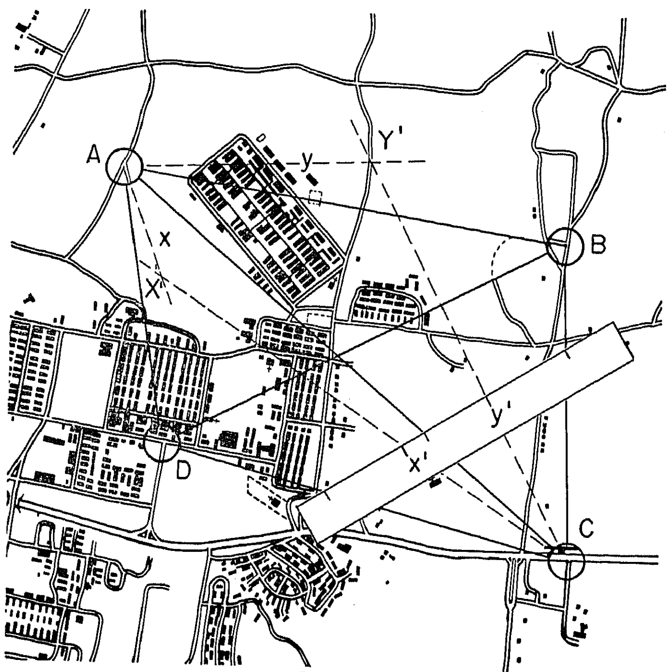


(2) Map

Figure 28. Paper strip method.

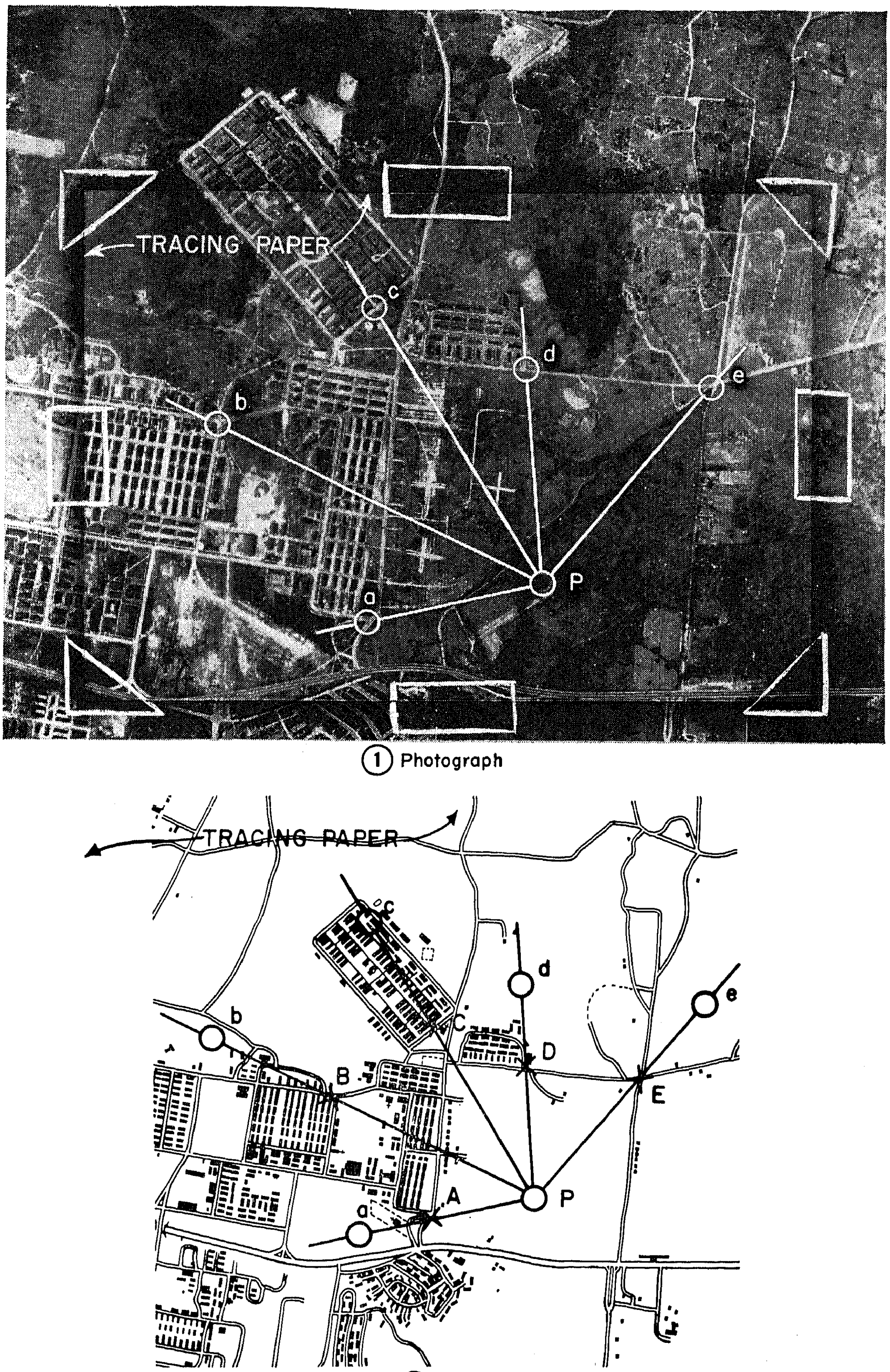


(3) Photograph



(4) Map

Figure 28—Continued.



(1) Photograph

(2) Map

Figure 29. Tracing paper method of resection.

ences in flying heights between successive exposures have no effect on the principle that angles measured about the principal point on a vertical photograph are true horizontal angles. If tilt exists in the photograph, then this principle no longer applies. Points on a tilted photograph are displaced because of both relief and tilt. Furthermore, relief displacement on a tilted photograph radiates from the nadir point and tilt displacement radiates from the isocenter. Under unusual conditions, there is no true center of rays on a tilted photograph about which horizontal angles can be measured when the terrain is perfectly flat; however, angles measured about the isocenter would be true horizontal angles. When the basic assumption applies, several factors act to reduce the tilt effects to a relatively insignificant amount. On the average, tilts very seldom exceed one degree, and maximum tilts rarely exceed three degrees. Even in rough terrain, tilt displacements caused by one degree tilt do not cause a measurable difference between angles measured about the principal point, the nadir point, or the isocenter. The fact that the direction of tilt is perfectly random tends to cancel out some effects of tilt upon the accuracy of the radial line plot.

(1) Assume it is desired to locate object A (fig. 30) appearing on 2 overlapping photographs. Identify on the map and on each of the 2 photographs 3 points which will serve to orient the photograph with respect to the map. A different set of points may be selected for each photograph or the same identical points, as X, Y, and Z shown in 1, figure 30. The points selected should be well out from the center of each photograph and so distributed that the rays drawn from them to the center of each photograph provide good three-ray resection. Points grouped too closely cause acute intersection angles between the rays drawn to the center of the photograph and make accurate work difficult.

(2) Enclose the 3 points selected on the photograph and the map in small triangles. Enclose the object A to be located on the map on a small circle on each photograph.

(3) Place a piece of vellum over the map and mark on the vellum the map position of the points X, Y, and Z.

(4) Locate the principal point on each photograph and label them C_1 and C_2, respectively. Draw rays from the principal points to points X, Y, Z, and A in each photograph (2 and 3, fig. 30).

(5) Place the vellum over photograph No. 1 and orient it so that the points X, Y, and Z marked on the vellum will fall on the rays drawn on the photograph through the images of those points (X_1, Y_1, and Z_1). Trace on the vellum the ray drawn through the object A_1 (4, fig. 30).

(6) Next, place the vellum over photograph No. 2 and orient it so that the points X, Y, and Z marked on the vellum again will fall on the rays drawn on the photograph through the images of those points X_2, Y_2, and Z_2. Trace on the vellum the ray drawn through the object A_2 (5, fig. 30).

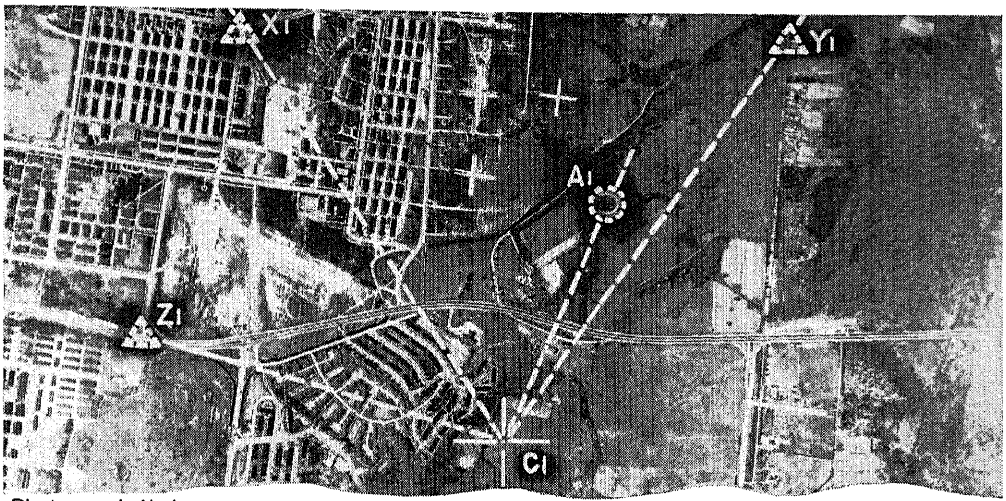
(7) The intersection of the two rays through the objects A_1 and A_2 on the vellum plots the position of A to the scale of the map. Place the vellum over the map and orient it so that points X, Y, and Z on both coincide, and prick point A onto the map (6, fig. 30).

e. Grid Method. The grid method is not applicable to oblique photographs nor will it eliminate the effect of displacements of position caused by relief.

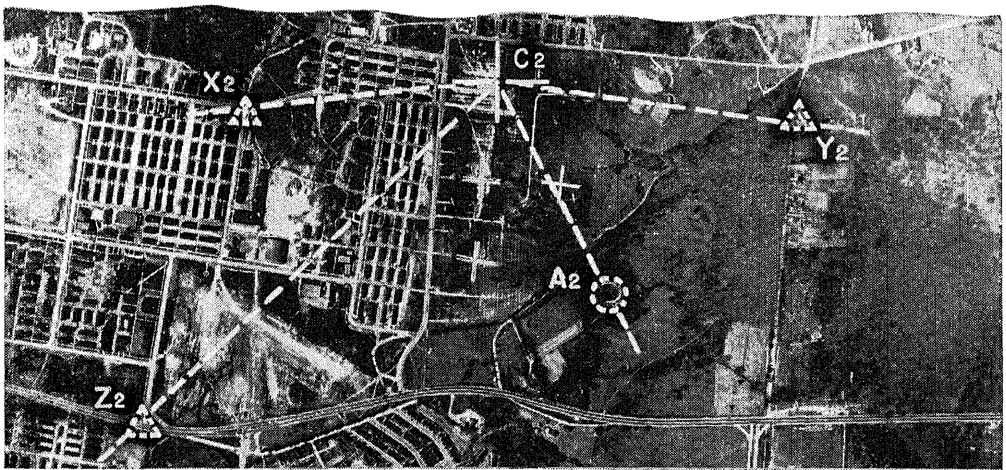
(1) Select around the margin of the photograph 4 well-distributed points, such as A, A_1, I and I_1 in figure 31, which can be identified on the map. Join the 4 points on both the photograph and map by straight lines to form a four-sided homologous figure. Divide the opposite sides of the two figures into the same number of equal parts ½ to 1 inch long.

(2) Joining the divisions laid off, draw on both the photograph and on the map grids which serve to subdivide the respective areas into the same number of small homologous figures. Copy in

Map ①

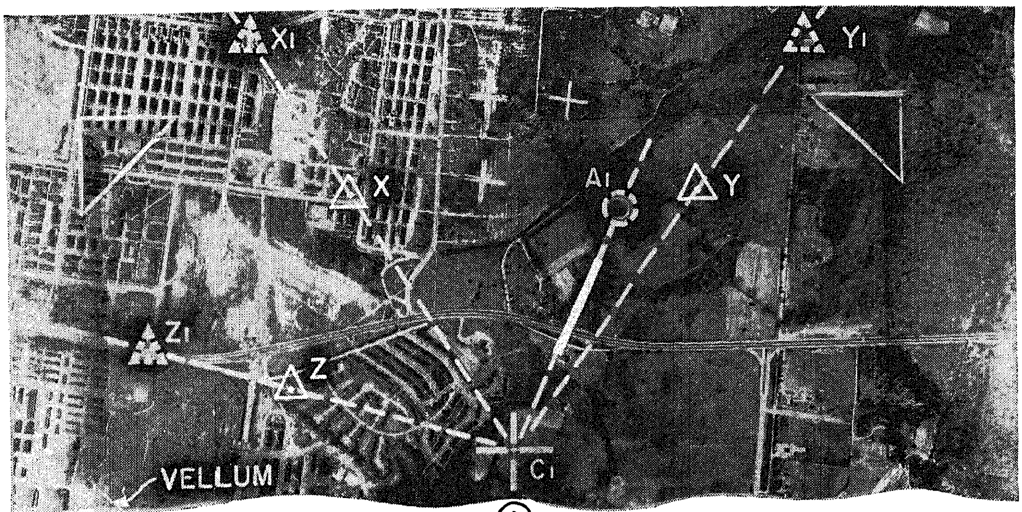


Photograph No. 1 ②



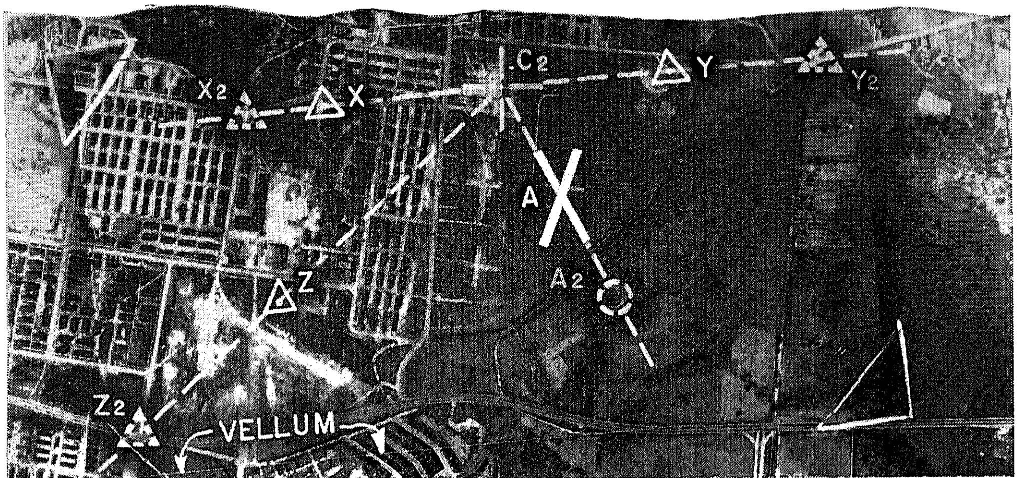
Photograph No. 2 ③

Figure 30. Radial line method of restitution.



Photograph No.1

4



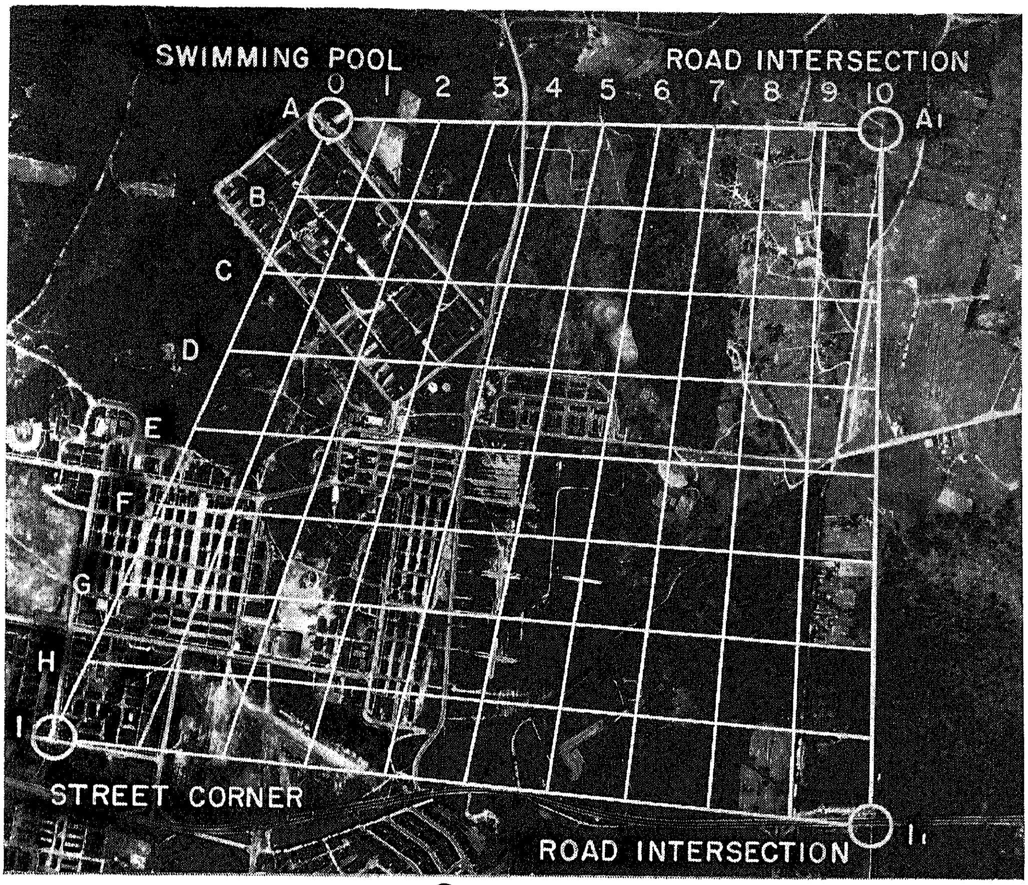
Photograph No.2

5

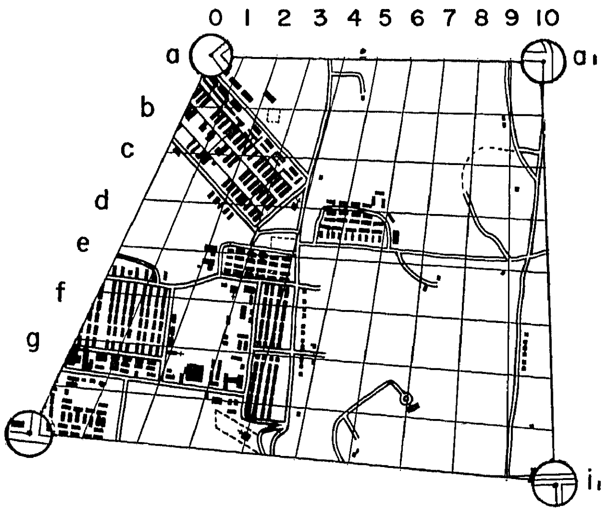
Map

6

Figure 30—Continued.



(1) Photograph



(2) Map

Figure 31. Grid method.

homologous relation the detail in each grid subdivision of the photograph into the corresponding grid subdivision of the map.

f. Triangular Division Method. This method may be used to rectify either a tilted or an oblique photograph. It is based upon the theory that straight lines on the map appear as straight lines on the photograph. It will not eliminate the effect of displacements of position caused by relief.

(1) Select 4 points, such as A, B, C, and D in figure 32, on the photograph which can be identified on the map and are so distributed as to include the area under consideration.

(2) Join these points with straight lines to form a 4-sided figure such that the opposite sides when extended, will meet in points F and G at a convenient distance. If these points fall off the photograph, they must either be extended onto another piece of paper or a large tracing-paper overlay used. Draw the diagonals AC and BD. Through their intersection O, draw lines FH and GI from F and G, respectively. In addition to the 4 control points originally selected, there are now 5 more points—F, G, H, I, and O—the positions of which are fixed. The figure ABCD has been subdivided into 4 smaller 4-sided figures.

(3) Draw diagonals in each of these and continue the process until the "controlled" subdivision of the area results in triangles of suitable size, usually with about 12.7 mm sides. Using the corresponding points a, b, c, and d on the map or on an overlay traced from the map, proceed similarly to produce the same number of homologous triangles. Finally, copy into the triangles of the map figure the corresponding detail as it appears in homologous relation in the corresponding triangles of the photograph figure.

g. Alternate Triangular Division Method. When more than 4 points of control are available, this method is simple and can be done in less space. On an overlay, trace from a map a large number of well-distributed control points, such as a, b, c, d, e, etc. (fig. 33), which can be identified readily on the photograph. Draw lines to join these points as they appear on the map and the photographs, respectively, producing homologous figures. Using diagonals as necessary, carry the subdivisions further to produce triangles small enough for the desired accuracy without causing undue congestion. Copy the detail from the photograph triangles to the corresponding map triangles. Figure 33 illustrates the mechanics of the method in its application to the restitution of an oblique photograph.

41. Vertical Sketchmaster

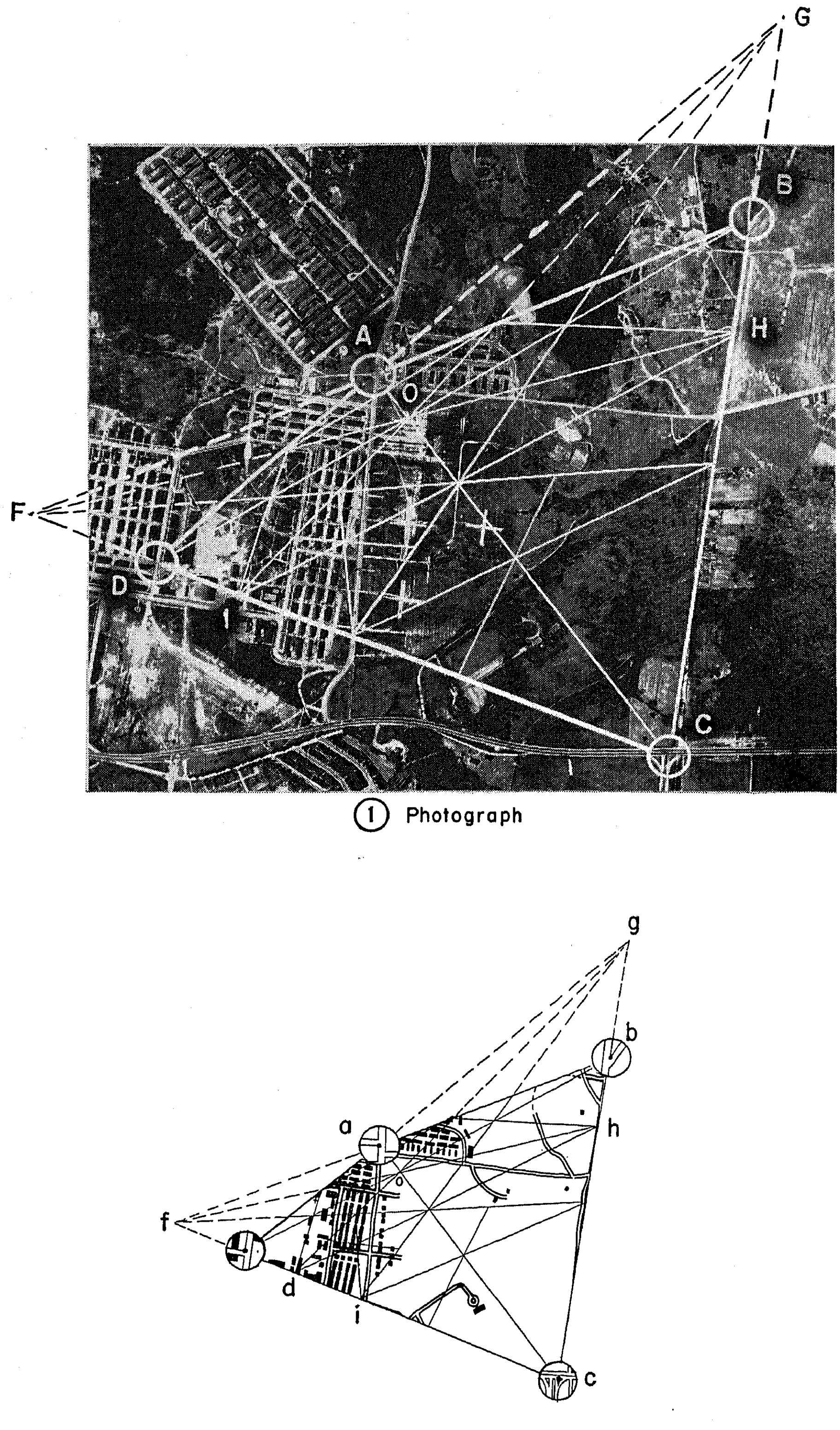
a. Use. The vertical sketchmaster is one of the instruments used to plot planimetric detail from vertical photographs. It is used when a direct transfer from photograph to manuscript by tracing is not practicable. The limiting reduction of scale between the photograph and the manuscript is approximately one-half. Before the sketchmaster can be used, the planimetry on the photographs must be delineated. Figure 15 shows a vertical sketchmaster in operation.

b. Principle. The basic principle of the vertical sketchmaster is that of a fully reflecting projector. The instrument contains a fully reflecting mirror which reflects the image of the photograph onto a second mirror which in turn reflects it onto the eye. The second mirror is semitransparent, so that the operator placing his eye over the eyepiece sees the image of the photograph and at the same time the compilation manuscript upon which the instrument was placed (fig. 16). Actually, it appears to the operator as though the photo image were located on the base plane or compilation manuscript. A small amount of tilt in the photograph can be corrected by varying the length of the legs.

c. Orientation and Operation.

(1) It is first necessary to clamp the photo in the frame provided on the instrument. It may be necessary to trim the photo before clamping in position.

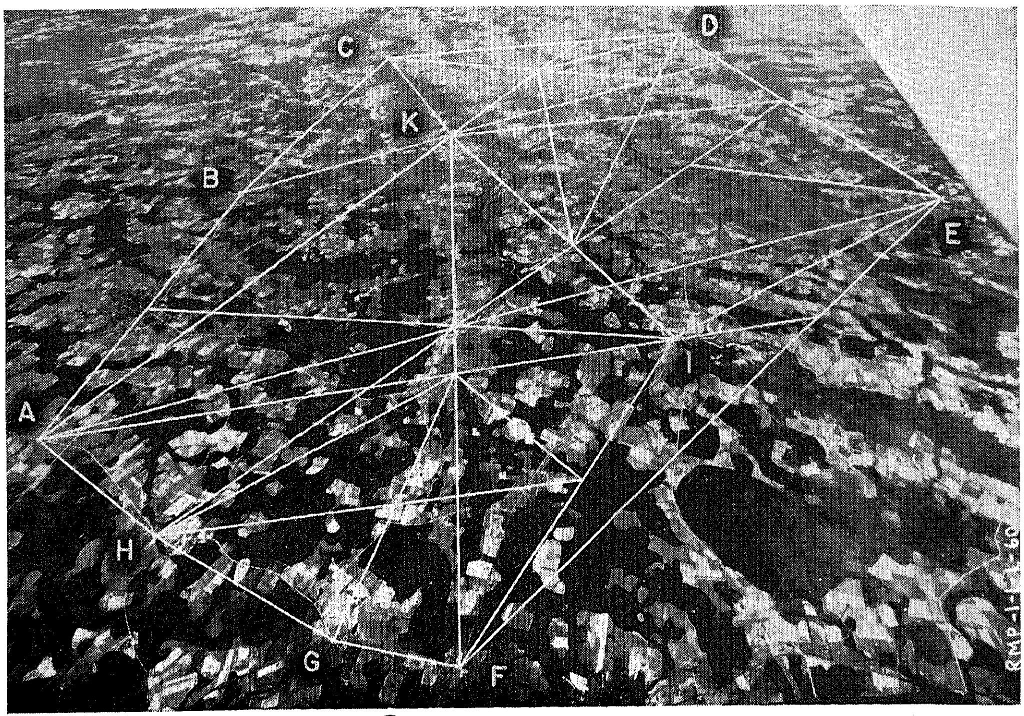
(2) The orientation of the vertical sketchmaster is accomplished by means of the principal and pass points (par. 84*a*). The legs of the instrument are



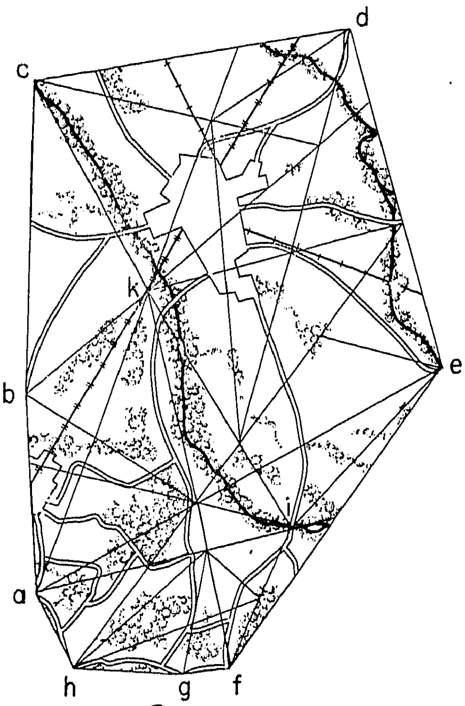
(1) Photograph

(2) Map

Figure 32. Triangular division method with 4 points.



(1) Oblique photograph



(2) Map

Figure 33. Triangular division method with more than 4 points.

adjusted until the principal and pass points of the photo are superimposed upon the corresponding points of the compilation manuscript or the tracing paper worksheet. If the manuscript appears to move with respect to the photograph when the eye is moved, correction lenses must be inserted beneath the semitransparent mirror to eliminate parallax and bring the apparent manuscript plane into focus with the photo plane. This will usually occur when the instrument is used to transfer detail at a ratio other than 1 : 1. Interchangeable meniscus lenses of various powers are provided with the instrument. These lenses have superior resolution and distortion characteristics.

(3) If it is impossible to get all the pass points and the principal point circles to interlock, then the orientation must be done for smaller groups of points at one time (for example, two pass points and the principal point).

(4) With the orientation completed and the planimetric detail seemingly superimposed on the worksheet, detail will be traced using colored pencils corresponding to the color scheme desired for the delineation of planimetry. When the orientation is for small groups of points, the detail is drawn within that area only. The sketchmaster is then reoriented over another set of points and the same procedure followed until the entire area of the vertical photograph has been sketched in.

42. Vertical Reflecting Projectors

a. Use. The reflecting projector is an instrument which is used to project detail from photographs, sections of opaque maps, and other printed data onto a copying table. It is used in map compilation and revision to transfer detail from source material of varying scales to the desired compilation scale. Several models of this instrument are employed—one being the stationary model used in garrison or base type operations, and the others serving a dual purpose of being employed in this manner or capable of being van mounted and having an automatic focusing device. The instruments are also furnished with interchangeable felt-faced holders for rollmaps or photographs.

b. Description. The photograph or map to be traced is placed in this instrument at the front of the enclosed chamber. A 45° mirror reflects its image through a lens to the table below. The photograph is illuminated by incandescent lamps inside the chamber, which may be shifted up and down on the columns by an electric drive to adjust to the scale of the compilation. If the projector is not of the automatic focusing type, provision is made for manually adjusting the lens for focus. This instrument has a magnification range from .33 diameter to 3.5 diameters.

c. Operations of Projector.

(1) Plug the cord into a wall socket.
(2) Insert the map or photo into the holder.
(3) Turn on the ventilation system.
(4) Turn on the rheostat slowly.
(5) Adjust and focus.
(6) Trace detail.
(7) Turn off the rheostat slowly.
(8) Turn off the ventilating system.
(9) Unplug.

43. Multiplex

a. Use. The multiplex method of mapping is one of the most precise methods used today by topographic troops for the preparation of topographic maps from aerial photographs. Being an optical projection system, it is capable of eliminating distortion that is inherent in other nonstereo mapping methods employing aerial photography. The multiplex method is suitable for preparing topographic maps of all scales, the largest scales being limited by the lowest altitude at which mapping photography can be obtained. It is also suitable for large-scale planimetric mapping where great position accuracy is desired. It is one of the mapping methods used by topographic troops by which contours can be plotted from aerial photographs to a high degree of accuracy.

b. Description. In the multiplex method, two overlapping photographs are projected onto a map sheet by means of two projectors—one for each photograph. The photographs that are

placed in the projectors are transparent positive glass prints, which are considerably smaller than the original film negatives. A blue-green colored filter is placed in the left projector and a red filter is placed in the right projector. The operator wears spectacles whose left lens is green and the right red. When the two overlapping photographs are projected onto the map sheet and the operator views these projected images through his spectacles, he sees a three-dimensional image that looks like a relief model of the ground surface. By means of a movable device called a tracing table, the operator can locate points or trace contours on the stereoscopic model. A drafting pencil is attached to the tracing table so that points for establishing the planimetry or plotting the contours can be drawn directly on the map sheet as the tracing table is moved on the stereoscopic model. A detailed description of the principles and operations of the multiplex is contained in TM 5–244.

CHAPTER 4

FINAL DRAFTING

44. Plastic Scribing

The two methods most generally used in this field are scribing, and blueline board and overlay drafting. Plastic scribing is the primary method of drafting.

45. Plastic Scribing Equipment

The procedures developed for plastic scribing allow considerable flexibility in their application to fit particular circumstances. The procedures recommended in this manual should be satisfactory for almost all military mapping organizations and operations. It should be emphasized that plastic scribing is a relatively new field; developments may be anticipated which will affect techniques and equipment.

a. Description. The scribe-coated plastic sheets, on which the guide images of the map manuscript are photographically reproduced as reverse positives, are made of polyethylene terephthalate plastic (Mylar). Scribing on these sheets is performed with the instruments and accessories furnished in Drafting Equipment Set No. 13. This set has all the instruments necessary for one cartographic draftsman to perform all operations involved in scribing the coated sheets.

b. Characteristics.

(1) The basic scribing instruments of Drafting Equipment Set No. 13 (Plastic Scribing) is the combination rigid and swivel scriber shown in figure 34. It has a mechanism for controlling pressure on the scribing point. Three adjustable ball-bearing feet support the body of the instrument and maintain the vertical orientation of the scribing point. Interchangeable point chucks provide for either rigid operation, as shown in figure 34, or swivel operation, as in figure 35. Figure 36 shows the pen type scribing instrument which is designed for rigid operation only and is used for most fine line work and for symbolization along with the map symbol templet. A detachable lens for enlarging the working area is also furnished. The measuring magnifier shown in figure 37 contains English and metric scales

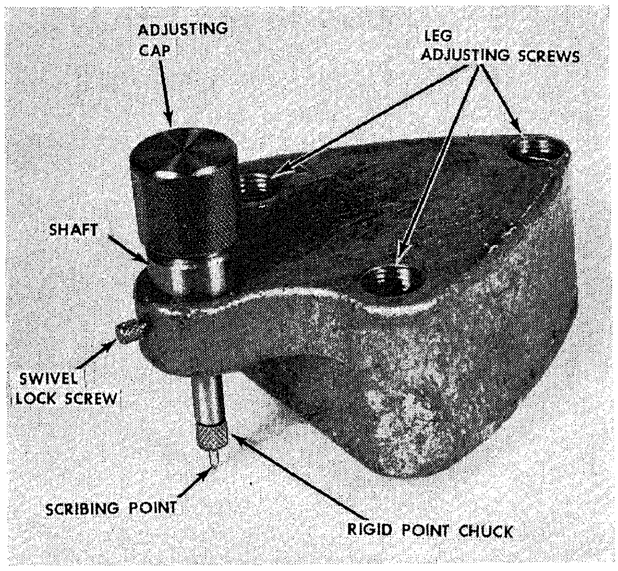


Figure 34. Scribing instrument, combination rigid and swivel, set up for rigid operation.

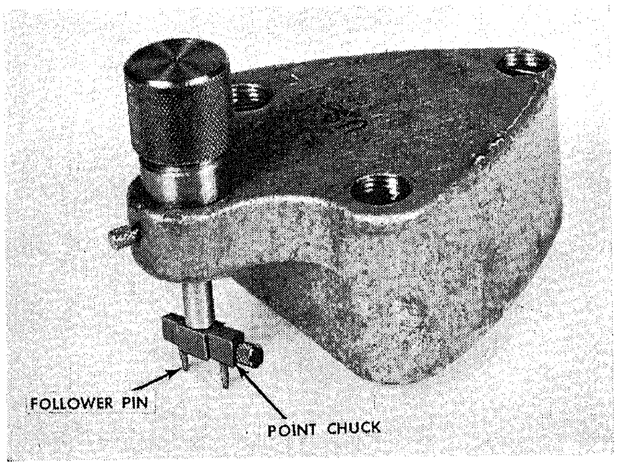


Figure 35. Scribing instrument, combination rigid and swivel, set up for swivel operation.

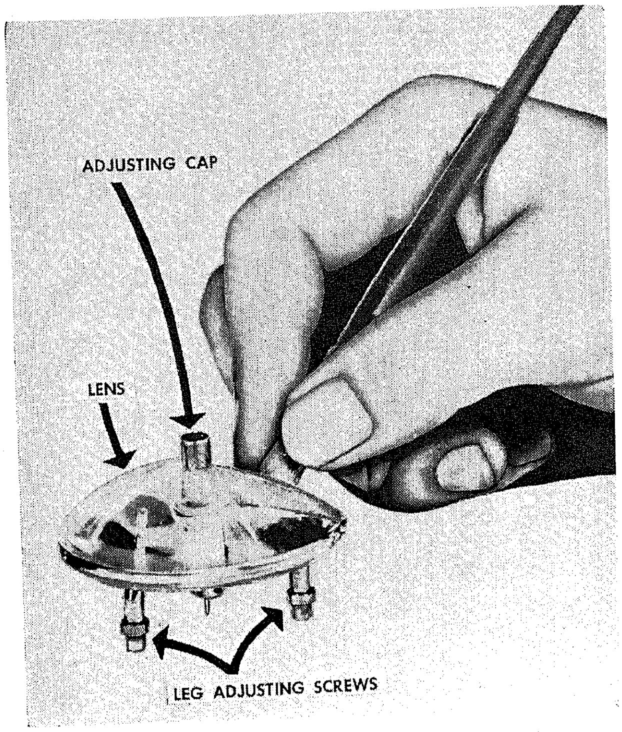


Figure 36. Scribing instrument, rigid, pen type.

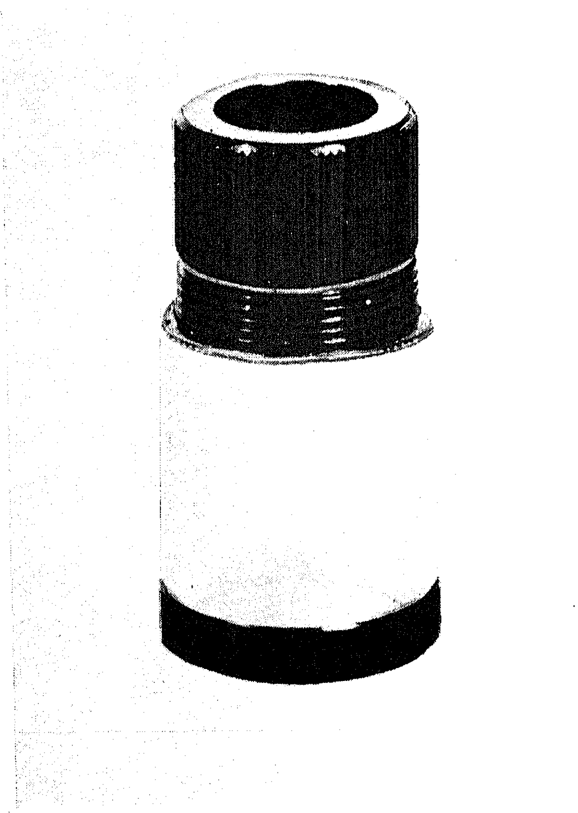


Figure 37. Line-weight magnifier with measuring reticle.

and line-weight gages for direct inspection of scribed work. Figure 38 shows the plastic templet furnished, which is designed for use with the pen type scribing instrument. This templet has cutouts to enable the scriber to produce a majority of the map symbols that are difficult to scribe freehand. The point dispenser illustrated in figure 39 facilitates quick selection of the desired point or tool attachment by rotating the top to the proper hole and inverting the dispenser. The dispenser has 12 scribing points, the swivel or rigid chuck for the combination scribing instrument, and the detachable pin for the swivel chuck. The scribing points consist of a corundum (synthetic ruby) tip fixed in a stainless steel shaft and ground to exact dimensions. There are three basic types: rigid round, spade, and multiple line. Five rigid round points are furnished, graduated in increments of 0.002 inch from 0.002- to 0.010-inch tip size. These points may be used interchangeably in either of the scribing instruments. Three spade points with 0.012-, 0.018-, and 0.03-inch tips are included. These are used in the swivel chuck of the combination instrument, as are the four multiple-line points. The correction pencil furnished is a paper-cased, spiral-wound, china-marking type for opaquing errors in the scribe lines up to 0.01 inch in weight.

(2) The scribe-coated plastic currently furnished to topographic organizations is an orange-pigmented, paint-like coating on polyethylene terephthalate (Mylar) sheeting 0.0075 inch thick, in sheets measuring 24 by 30 inches.

(3) Mylar sheeting is a transparent plastic for preparing overlays for lettering and area tints. It is a strong, dimensionally stable sheeting matching the scribe-coated plastic in thermal and hygroscopic expansion characteristics.

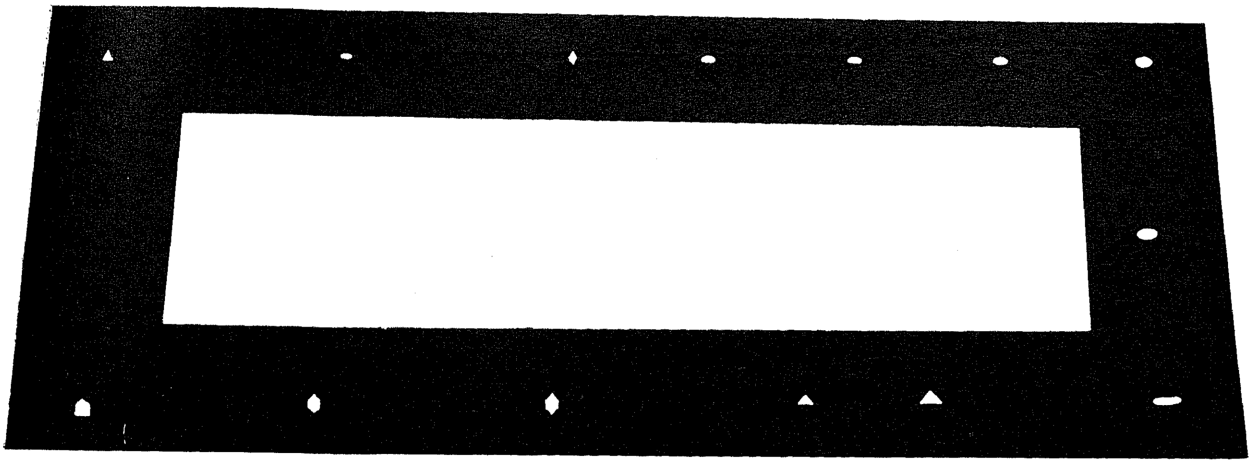


Figure 38. Plastic map symbol templet.

(4) For special applications, a special coated Mylar sheeting is furnished. A dyed albumin or gelatin coating is applied instead of the paint. Where large areas are to be cleared, the outline is scribed or etched through the peel- or strip-coat and the circumscribed area can be lifted and peeled.

(5) Opaquing fluid is for opaquing area tints on overlays and for correction of line and area work larger than 0.25 mm in dimension. A lacquer base orange colored fluid (stabilene) is used.

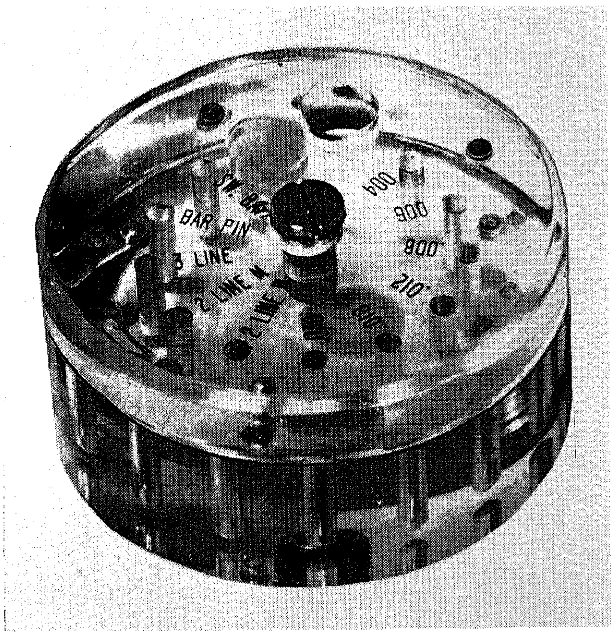


Figure 39. Plastic point holder with selector type top.

(6) Drafting light tables are made with glass tops and fluorescent illumination beneath.

c. Capabilities and Limitations. Set No. 13 has enough scribing equipment to enable one cartographic draftsman to scribe all freehand line work. A majority of the common map symbols can also be scribed directly with this set, using the map symbol templet furnished.

d. Reproduction Equipment. The equipment required for processing the guide images on the scribe-coated plastic is essentially the same as that required for reproducing an image on blueline boards: photographic equipment, whirler, vacuum frame, arc light, blueline chemicals, and plate processing chemicals. The vacuum frame is also used in a darkroom for making contact negatives and positives. The vacuum back of the 24- by 30-inch mobile process camera can be used to hold a piece of film with a scribed sheet over it. If the vacuum back is used, a large sheet of clear acetate may be used to cover and hold flat the film and scribed sheet. An auxiliary light source is required to make the contact exposures. A point light source is desired, but an incandescent bulb will do. A point light source may be made by placing a light bulb in a can with a 6-mm hole in the bottom.

46. Procedures

a. Operations. The diagram shown in figure 40 covers the steps involved in a typical scribing color separation operation.

b. Manuscript to Scribe-Coated Plastic.

(1) *First step.* The first step in the plas-

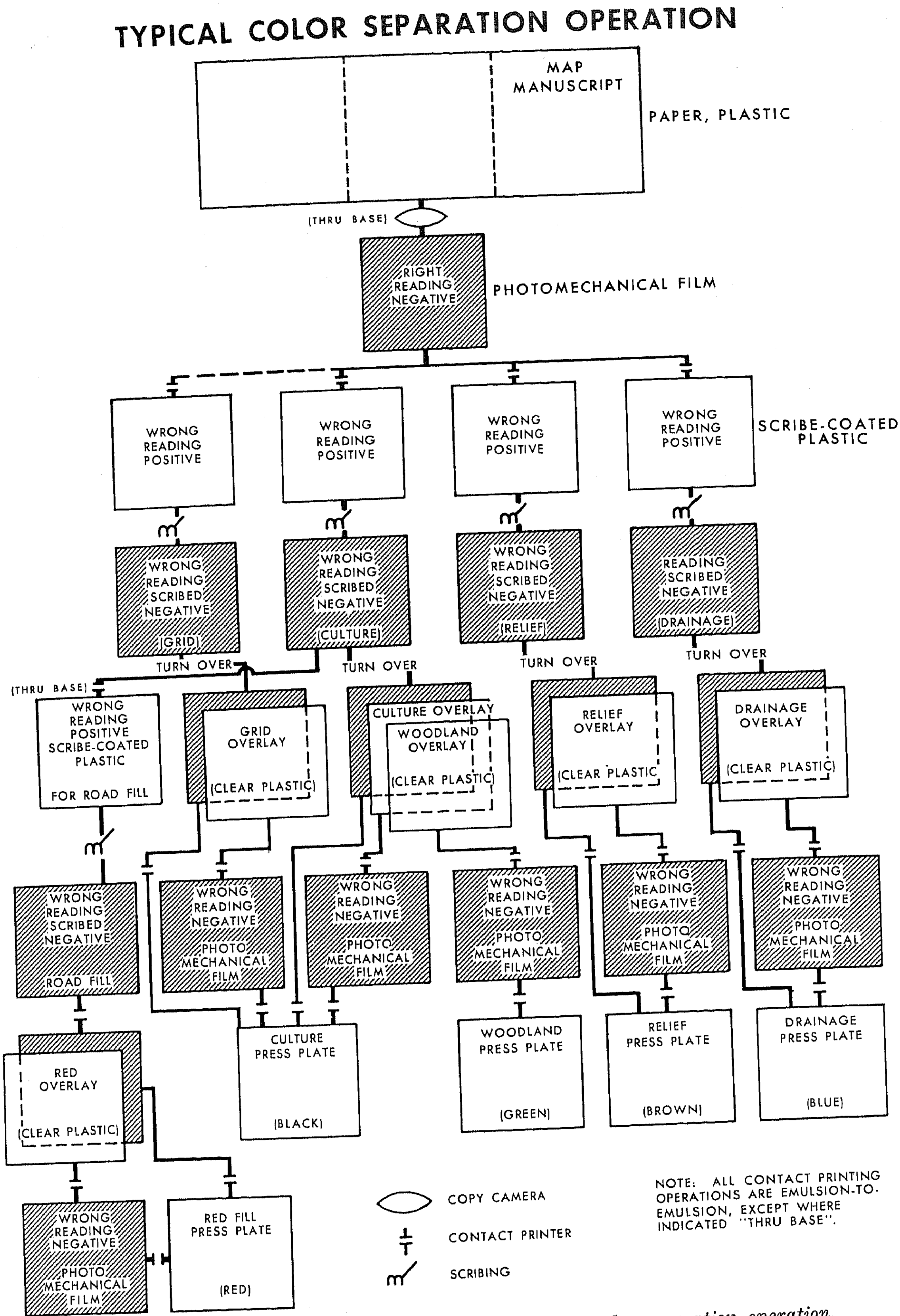


Figure 40. Schematic diagram showing typical scribing color separation operation.

tic scribing process is the application of a blueline image of the map manuscript to the required number of coated sheets, one for each color that will appear on the final map. The camera negative made from the manuscript for this step should be exposed through the base so that a right reading negative (reads right when facing the emulsion side of the film) is obtained. Future steps in the operation are thereby made easier.

(2) *Guideline images.* When the scribing process is used to prepare the printing plates for map reproduction, there must be at least one scribe sheet for each plate that prints an individual color. Each of the scribe sheets has a photomechanically applied image that is used to guide the cartographic scriber. The chemicals and techniques used to apply these guide images are described in TM 5–245.

(*a*) *Coating.* The coating procedure, using the wipe-on technique, is as follows:

1. Remove all grease, oil, and fingerprints from the scribe-coated plastic sheet by washing with a solution of trisodium phosphate or similar detergent. Pumice powder used with a sponge or cotton is also effective in degreasing. Rinse the sheet thoroughly, removing excess water and cleaner or pumice powder with a squeegee or sponge and fan dry.

2. Tape or clamp the sheet to the work table with the scribe coated side up. Pour a pool of the mixture onto the center of the sheet and spread it out evenly over the entire surface with a cheesecloth pad. Smooth the coating out with firm strokes, using light pressure to remove as many bubbles and obvious streaks as possible. After the coating has been smoothed, it may be dried with an electric fan.

(*b*) *Exposure.* The coated scribe sheet is exposed 8 minutes using a 110-ampere, single-arc lamp placed 48 inches from the vacuum frame. Corresponding exposures for different conditions of illumination intensity and distance can be worked out on a trial and error basis.

(*c*) *Development.* The exposed sheet can be developed in a large tray or can be flushed in the sink with developing solution from a jug. The image should appear immediately upon contact of the sheet with the developer. Flush briefly with a water spray to remove any residual acid or background, and allow to completely air dry.

(*d*) *Reclaiming coated sheets.* The image can be removed by soaking the sheet in a 10-percent solution of ammonium hydroxide and rubbing with a sponge or cotton. A detergent or pumice powder will help remove any residual image. The sheet should be flushed with water and dried before reusing.

c. Preparation for Scribing. Before scribing a given feature, the point required to produce the proper line-weight is selected. The scribing instrument is adjusted by leveling screws and spring pressure adjustment as follows:

(1) Set up the combination instrument as shown in figure 34 for rigid points, or as shown in figure 35 for points used in swivel operations. For rigid operation, turn the swivel lock screw clockwise far enough to engage a groove in the shaft so that a vertical motion, but not rotation, of the point against spring pressure is possible. Adjust by turning the adjusting cap on top of the shaft counterclockwise until no scribing in any direction is done when the instrument is moved over a test piece of scribe-coated plastic. Then turn the cap clockwise until the scribing point begins to cut through the coating to expose the base plastic. Move the instrument along its longitudinal axis to scribe a short line and examine the scribed line with the line-weight magnifier for evidence of incomplete clearing. If the left side of

the line should be incompletely cleared, shorten the left front leg and lengthen the right front leg by turning the adjusting screws one-half turn. Reverse these motions if the right side of the test line is incomplete. Next, move the instrument along its short axis and again examine the test line. Shorten or lengthen the rear leg of the instrument to achieve clear scribing in this direction. Then set the spring at the optimum scribing pressure by turning the adjusting cap one full clockwise turn past the point at which clear scribing is just possible. The procedure for leveling and adjusting the combination instrument with the swivel point chuck is similar, except that leveling is usually more critical with swivel points, and the swivel lock screw must be backed off to permit both rotation and vertical motion of the shaft before adjustment is started.

(2) Adjustment and leveling of the pen type scribing instrument follow the same general steps outlined for the combination instrument in rigid operation.

d. Scribing. Actual scribing with either instrument consists of tracing with the cutting point all details which are to appear in a given color on the finished map. The linework and symbols which can be scribed on each sheet are scribed with the instruments and symbol templet as follows:

(1) *Culture.* All features which will appear in black on the finished map are included on this sheet, except the grid or data pertaining to the grid. The neatline is scribed on this sheet and serves as registration for all subsequent sheets. The primary grid is scribed on an additional sheet to avoid rescribing the entire culture sheet. Make dashed lines by opaquing across the scribed lines at appropriate intervals. Touch up road intersections with India ink, using a fine-line pen of the crowquill type. After completion of the scribing, debris is cleaned by lightly rubbing with absorbent cotton. Make corrections by touching up with the correction pencil and rescribing.

(2) *Grid.* The major grid and overlapping grid ticks, if required, which will appear in black on the finished map, will be scribed on this sheet. Grid lines that interfere with preferential grid numbers are opaqued.

(3) *Relief.* All hypsographic (brown) features are scribed on this sheet. All scribable brown marginal data are included.

(4) *Hydrography.* Features to appear in blue on the finished map are scribed on this sheet, although only the shorelines of open-water areas, such as double-line streams, lakes, and seas are delineated.

(5) *Red road.* The technique for scribing the red road fill is to scribe the culture sheet and then photomechanically transfer the scribed image to a second scribe sheet. The transferred image can then be used as a guide to scribe the red road fill. If the image is transferred to a peel coat sheet, the area to be deleted is lifted or peeled. A translucent scribe sheet can be overlayed on the scribed culture sheet and the red road fill scribed directly, using the underlayed culture sheet as the guide.

e. Overlays. Features such as lettering, area symbols, tints, and map symbols not scribable with the templet are added to overlay sheets. An overlay sheet is plastic sheeting taped to the back of the scribed sheet. When sticking up the information on the overlay, the scribed surface of the scribe coat sheet is face downward on a light table, and the stickup material is secured to the surface of the overlay sheet so that it is right reading. After this, both the scribed sheet and overlay sheet are sent to reproduction where the overlay sheet is photographed onto a piece of film to produce a negative. This negative and the scribed sheet are then used to make the press plate. Stickup material is added to the overlay sheets as follows:

(1) *Lettering and symbols.* All lettering and marginal data except that per-

taining to grids, Zip-a-tone or Stic-pat, and symbols not readily scribable on the culture sheet are stuck up in positive form on a transparent overlay sheet taped firmly to the back of the scribed culture sheet. Registration marks are inked on the overlay sheet, and the detail on the scribed culture sheet which interferes with preferential lettering or symbolization is opaqued out. The two sheets are now ready for processing and are sent to the reproduction unit.

(2) *Grid data.* All primary grid data that cannot be scribed are stuck up in positive form on a transparent overlay firmly taped to the back of the scribed grid sheet. Registration marks are inked on the overlay to agree with the grid negative. The negative and overlay are sent together for processing.

(3) *Contour number.* All contour numbers, unchecked spot elevation numbers, Zip-a-tone or Stic-pat, and applicable marginal data are stuck up in positive form on a transparent overlay firmly taped to the back of the scribed relief sheet. Registration marks are scribed on the relief sheet and inked on the overlay, and the contour areas or other detail which interferes with the stickup numbers is opaqued out on a relief sheet. The relief and overlay sheets are sent together to the reproduction unit for processing.

(4) *Open water areas.* Lettering, numbers, overlapping grid coordinates, Zip-a-tone or Stic-pat, and marginal data are stuck up in positive form on a transparent overlay firmly taped to the back of the scribed drainage sheet. In addition, open water areas to appear in blue on the finished map are carefully opaqued on this overlay. Registration marks are inked and scribed, and drainage detail which interferes with preferential blue lettering or symbolization is opaqued out on the drainage sheet. The sheets are sent to the reproduction unit for processing. When large open water areas to appear in halftone are involved, the scribed drainage sheet is sent to the reproduction unit for preparation of a "through-the-base" contact reverse-reading positive of the scribed drainage detail on sensitized scribed coated plastic or a peel- or strip-coat base. The shorelines of open water areas are accurately scribed on this guide, and the scribe coating is removed in the areas by scraping with the widest spade point or with a metal eraser from the coated plastic, or by "peeling up" the peel coat layer.

(5) *Red boundary.* Red boundary overprint and built-up area are applied in Zip-a-tone or Stic-pat, or are opaqued on a transparent overlay firmly taped to the back of the scribed red road fill sheet. Registration marks are scribed and inked as described before. Both sheets are sent to the reproduction unit for final processing. Alternatively, large area-tint areas may be processed on a scribe-coated sheet, using the procedure in (3) above.

(6) *Vegetation.* Wooded areas, orchards, and other features to be printed in green are opaqued or stuck up with Zip-a-tone or Stic-pat on an overlay sheet, or both, which may be taped to the back of the culture-sheet and prepared prior to the preparation of the culture overlay described under (1) above. The vegetation overlay is sent to the reproduction unit to be processed by the methods described in *f* and *g* below for processing.

f. Alternate Stickup Procedures. In lieu of stickup and opaquing of transparent overlays, an alternate method is to prepare in the reproduction unit contact positive prints of each scribed sheet or photomechanical film and apply necessary stickup and opaquing to these film positives.

g. Reproduction Procedures.

(1) All overlay sheets which are sent to reproduction from compilation are contact printed onto a photomechanical film to produce high-contrast negatives. Exposures are made with the

stickup side of the overlay contacting the emulsion of the film. The point light source should be as far away from the film as is practical to prevent undercutting of the image. Processing is done according to standard procedures.

(2) Plates made from scribed materials generally require multiple exposures. Some of the information is recorded on the scribe sheet, while the remainder is on an overlay sheet from which a negative is made. Consequently, the scribe sheet and negative must be exactly registered (see TM 5–245).

h. Photomechanical Etching. This etching procedure chemically removes the scribe coating in those cases where a suitable master is available. The master is normally a film positive which can be contact printed from existing color separation film negatives or scribe sheet. The positive may also be made by applying information on transparent overlays.

(1) *Coating with resist.* The plate-coating machine, or whirler, is used to apply a uniform resist coating to the scribe sheets. This coating may also be applied by the wipe on method described in *b*(2) above.

(2) *Exposure.* The resist coated scribe sheet is placed in a vacuum frame in emulsion-to-emulsion contact with the desired positive master and exposed.

(3) *Developing the resist.* The resist coating is water soluble and it is necessary to carefully control the amount of water that contacts the resist until the etching operation has been completed. When development is completed, the image should be visible and appear undercut into the resist coating when viewed by overhead light. Etch the sheet as soon as possible after development to avoid humidity and temperature cracks in the resist coating.

(4) *Etching.* The entire image may be rapidly etched by using a large pad, liberally soaked with etch solution, and covering all of the sheet with a few sweeping strokes. If only small areas are to be etched, a hard ball of cotton on a stick may be used. Use a minimum of pressure on the developing pad to prevent erosion of the resist coating. Continued rubbing after a line has been etched may cause it to spread unevenly.

(5) *Finishing.* The resist is removed to prevent difficulties that might arise when the sheet is scribed subsequent to etching. A stream of warm water will rapidly remove the resist coating. Any color that may remain in the etched lines may be removed by a detergent. After being rinsed, the sheet may be fanned or hung to dry and is then ready for further scribing or press plate preparation.

i. Possible Application for Etching. Uses for the etching technique will vary according to the job to be done. Some suggestions are—

(1) *Duplicate scribed sheets.* If a duplicate scribed sheet is required for a revision or special purpose, it can easily be obtained by first making a film positive which is then used to etch a scribe coated sheet as just described.

(2) *Etching contour numbers.* To simplify subsequent operations, contour numbers can be etched into the contour sheet prior to scribing. The numbers are prepared in positive form on a transparent sheet overlayed on either the compilation negative or on the scribe sheet onto which the image has been processed. The scribe sheet is then coated with the resist solution and the positive is registered to the image and exposed in the vacuum frame. The scribe sheet is then chemically etched. After the numbers have been etched, scribing of the contour lines can proceed. This process greatly simplifies combining the contour lines with the contour numbers. Contour number registration problems are also eliminated from the plate-making stage.

(3) *Open areas.* Large solids, such as water areas and woods, can easily be etched into a composite sheet from a

positive prepared by photography or by drafting on clear plastic overlays.

(4) *Revision.* A combination of etching and scribing can greatly simplify many map revision jobs. One example would be revision of the contour negative. This could be accomplished by preparing and exposing a contour film positive to a resist coated scribe sheet and then selectively etching all areas that will remain unchanged. If selective etching is undesirable, the areas to be revised may be opaqued out on the contour negative prior to making the film positive mask. The resist coating is then removed and areas to be revised or changed are scribed with tools in order to complete a finished contour negative suitable for preparing a press plate. Since etching can be done by working on a light table and using a cotton swab, it is a simple matter to etch selected areas of all color separations that are subsequently affected by revisions occurring on related color separations for the same map sheet.

47. Maintenance and Spare Parts

a. Maintenance. Drafting Equipment Set No. 13 (Plastic Scribing) requires little maintenance. Preventive maintenance for this set's equipment consists of using the same care given all precision drafting instruments: periodic cleaning of the scribing instruments and lubrication once a month with a very small quantity of watch or instrument oil on the main piston. Oil should be applied with a matchstick or toothpick. The ball bearing feet on both instruments should be rotated by hand frequently and cleaned of debris. Scribing point tips are made of extremely hard corundum to resist wear and breakage, but they are not resistant to sudden impact. They should not be dropped or allowed to rest on metal or glass surfaces while in position in the scribing instruments. Plastic lenses for the scribing instruments are practically nonbreakable but are soft enough to be scratched severely if handled roughly or allowed to lie unprotected on gritty or dirty surfaces. The scribe-coated or peel-coated plastic should not be folded or sharply creased, and sharp-edge triangles and other drafting aids should be used with care on the plastic to avoid scratching the coating.

b. Spare Parts. Photomapping and drafting equipment sets contain spare scribing instruments and expendable scribing points, map symbol templets, and correction pencils.

48. Color Separation Drafting

a. Introduction. The secondary method of color separation is final drafting, of which there are two general processes used by the military services.

(1) *Blueline process.* In this process, the compilation sheet is photographically reproduced in light blue on metal-mounted, high-quality drafting paper. Separate drawings are then inked in black india ink directly on the blueline board for each color of the final map. Each drawing is photographed and a negative is developed.

(2) *Overlay process.* Plastic, tracing paper, or tracing cloth is used in the overlay method, in that order of preference. A sheet of the material selected is placed over a master copy. All detail to be included is then traced. It requires the same number of drawings as the blueline method, and the photographic, layout, and press plate processing are the same in both. A difficulty with this method is that the material, except for plastic, is not dimensionally stable.

b. Plotting and Drafting Equipment.

(1) *Needlepoint.* The accurate positions of plotted points are generally marked by pin-pricking the paper with a No. 10 needle filed down to a fine point and held in a pin vise (1, fig. 41). In plotting points, the draftsman usually holds the needle at approximately 45° to the plane of the paper, because the accurate location of the points is generally observed through a magnifying glass. The draftsman must take care to keep the needle sharp and not dig into the paper or drop it. To sharpen the needle, use regular emery paper No. 400A soft back for rough grinding and emery polishing paper No.

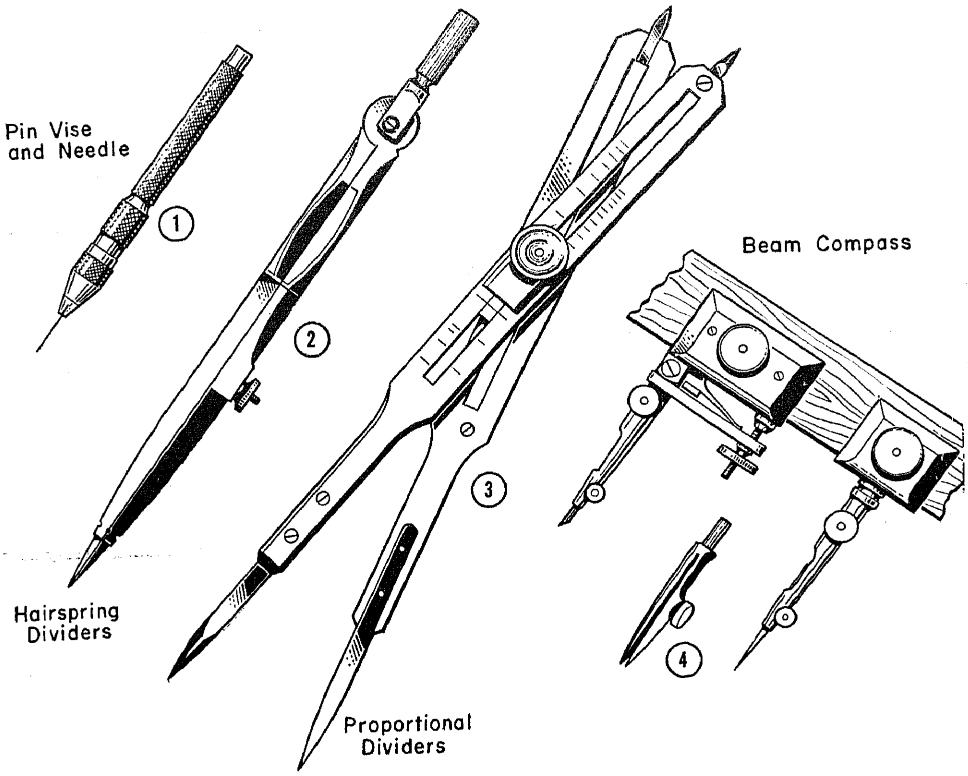


Figure 41. Plotting instruments.

4/0 for finish grinding. When polishing, rotate the needle in one direction constantly at the proper angle (not too sharp).

(2) *Magnifying glass.* Figure 42 shows a linen tester which is used to magnify detail in a congested area or to plot points accurately to .01 inch (.25 mm). In using a magnifier, the draftsman must take care to look through the center of the lens in a direction normal to the plane of the paper to minimize distortion. Lens tissue should be used for cleaning the lens. Leather cases are available for carrying magnifiers in the field, since the glass must not be scratched or chipped.

(3) *Hairspring dividers.* Hairspring dividers (2, fig. 41) are distinguished from plain dividers by having a screw adjustment on one leg which facilitates accurate settings. They are commonly used for the transfer of precise measurements.

(4) *Proportional dividers.* Proportional dividers (3, fig. 41) are used for enlarging or reducing according to any proportion. On one edge are divisions for setting to linear proportions. On the other edge are divisions for setting to circular proportions when dividing a circle (the diameter of which is measured by the large end of the dividers) into the desired number of equal parts.

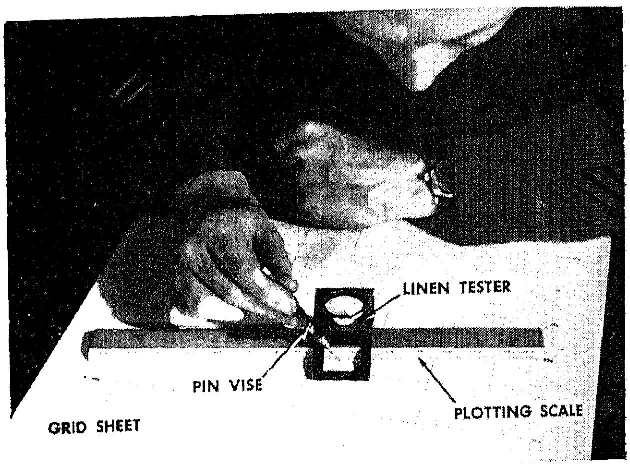


Figure 42. Plotting a point.

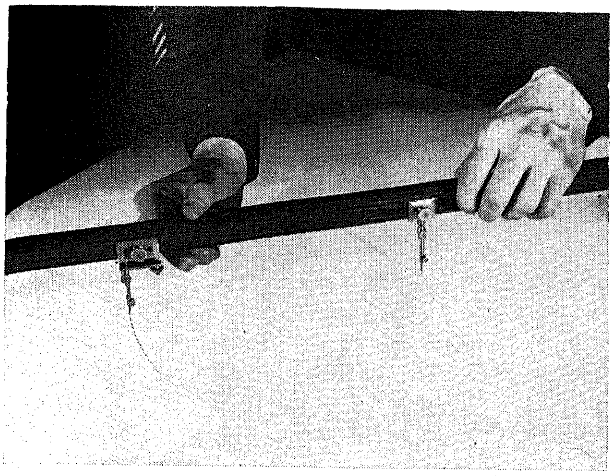


Figure 43. Drawing an arc with a beam compass.

(5) *Beam compass.* Beam compasses (4, fig. 41) are used when the radius to be drawn (fig. 43), or the distance to be laid off, exceeds the range of the ordinary compass or dividers. Beam compasses consist of 3 principal parts: steel points; interchangeable pen, pencil, or needlepoint with micrometer adjustments; and 1 or more bars, 18 to 70 inches long. These bars, to which the first two named parts are fastened, are made of hard wood or tubular metal with interlocking sections.

(6) *Plotting scales.* When standard scales are not usable, special plotting scales may be constructed. Figure 44 shows two plotting scales—the upper one for use on 1:20,000 maps or drawings and the lower one for use on 1:10,000 maps. Subdivisions of 1,000 units are marked on the bottom of each scale and may be measured at the left, or subgraduated, end to include units of 100 and units of 10. In constructing the lower scale, the length of the line is first drawn to its exact length.

$$AE=\frac{6,000\times 12}{10,000}=7.2 \text{ inches. The line}$$

AE is then subdivided into 6 equal parts, each part to represent 1,000 feet, and marked below the line. Ten horizontal lines, at equal spacing, are then drawn parallel to AE. Perpendicular lines to the parallel horizontal

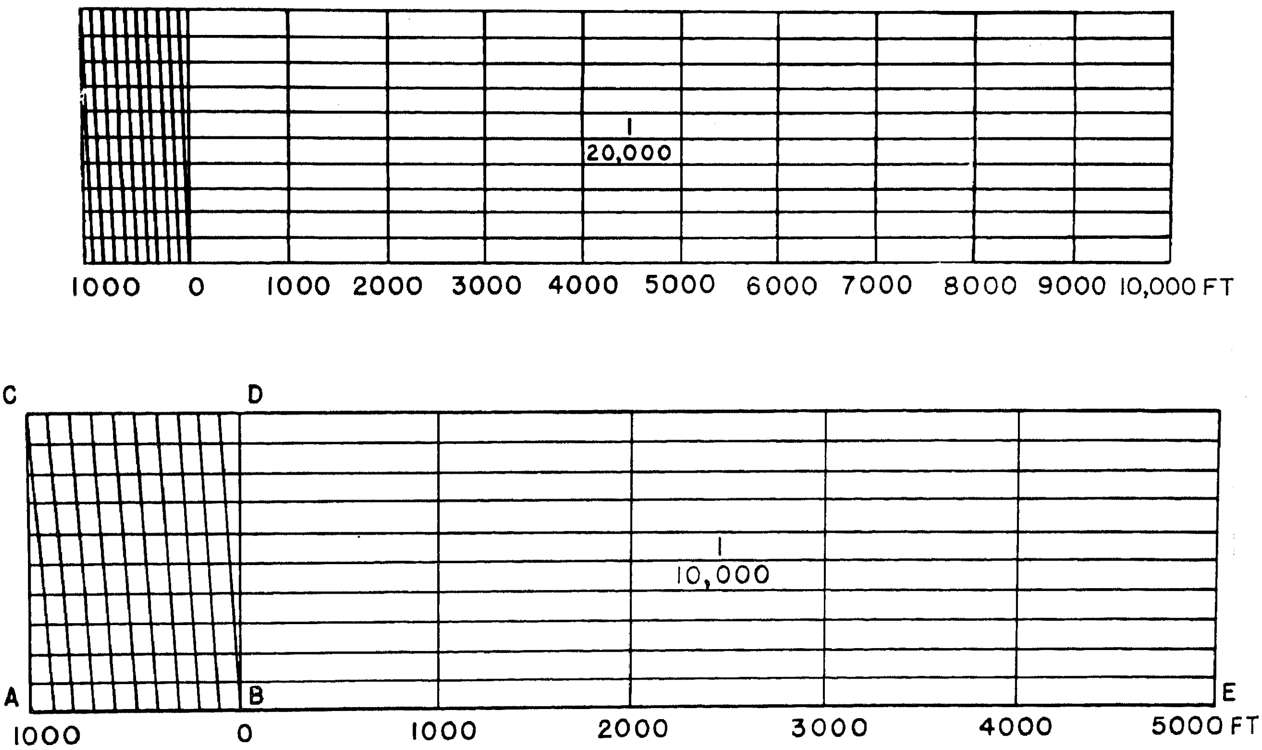


Figure 44. Plotting scales.

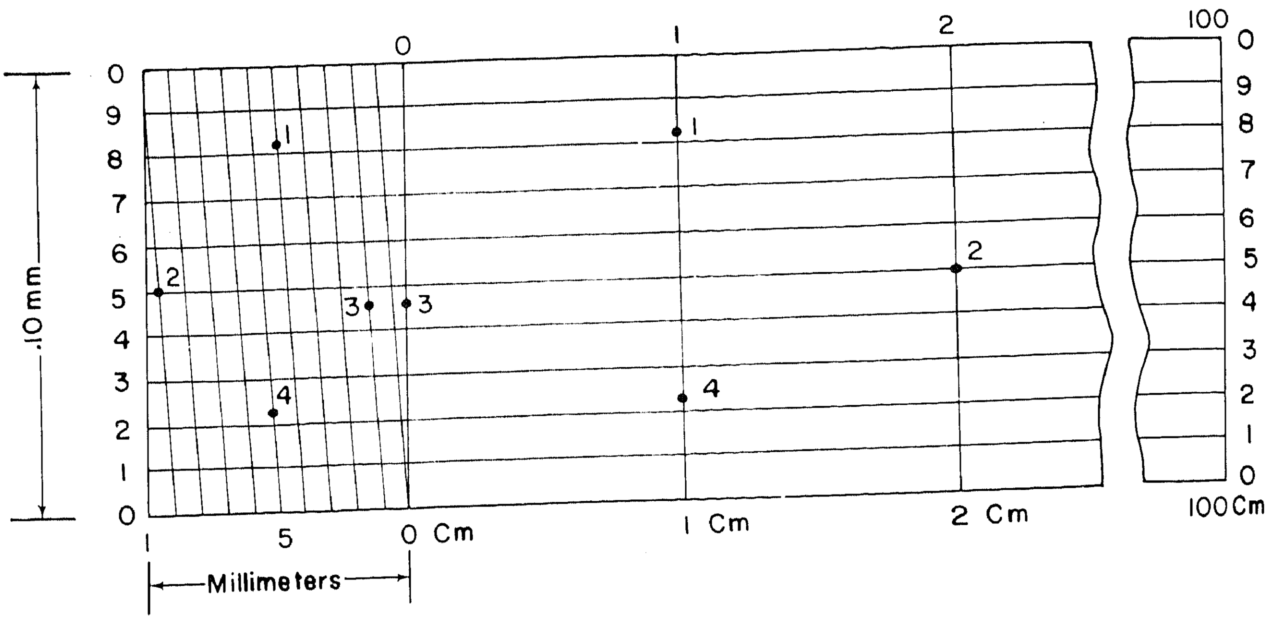
lines are then drawn at the 1,000 unit intervals. Line segments AB and CD are each subdivided into 10 units and the points joined obliquely as shown in the figure, completing the scale.

(7) *Invar plotting scales.* Invar is a special kind of steel alloy which has a low coefficient of expansion and contraction and thus remains at the same length over a wide range in temperature. Invar scales graduated to 0.01 inch are used for plotting points; when used with magnifiers, the positions of points can be estimated to the nearest 0.001 inch. Invar scales are used in conjunction with the beam compass. Figure 45 shows examples of measuring on the invar scale. Invar scales should be properly cased and never touched with the hands.

(8) *Metric scales.* For certain work, metric scales subdivided to suit particular conditions are available. A metric scale measures to 0.001 meter. Comparing its subdivisions (cm and mm) with the subdivisions of the engineer's scale, it will be seen that 25 mm are equal to appoximately 1 inch. Meter bars are also used often to check plotted grids.

(9) *Standard engineer scale.* The engineer scale is used to lay off distances when plotting control data by rectangular coordinates. Inches are subdivided into 10, 20, 30, 40, 50, and 60 parts with larger division lines for each group of 5 and 10 small units. Engineer scales are also used for laying out the border data for the map sheet in accordance with style sheet specifications and for measurements where the requirement for accuracy is not critical.

(10) *Protractor.* Protractors are used to plot or to measure angles. They are made of wood, celluloid, or metal. The latter are the most satisfactory and come in several sizes. The ordinary type is graduated into single degrees, while the more precise have verniers attached to permit the plotting or measuring of angles to single minutes of arc. The usual form is a semicircular arc graduated in degrees from 0° to 180°. The center of the graduated arc is marked so that it may be placed upon the vertex of the angle to be measured or laid off, with 0° of the scale on one leg of the angle. The required number of degrees can be



1. 1.482 Cm 2. 2.950 Cm 3. 0.145 Cm 4. 1.523 Cm

Figure 45. The invar scale.

read or marked on the paper in prolongation of the division.

(11) *Crowquill pens.* Crowquill pens are used for drawing lines and delineating detail. To get uniform line weights, the tips of the penpoints are sharpened to the width corresponding to the thickness of the line desired.

(12) *Line gage.* Figure 46 shows a line and road gage checking templet drawn on a sheet of acetate, which is used to check the widths of lines.

(13) *Ruling pens.* The ruling pen consists of two steel blades, a setscrew, and a handle. The blades are of equal length, pointed and sharpened at their lower ends. The points can be adjusted by means of a screw to draw a line of any desired width.

(14) *Bow pen and drop pen.* The bow pen is used to describe circles or arcs between 3 mm and 13 mm in radius. The drop pen is used to ink smaller circles about 1 mm to 3 mm in radius.

(15) *Contour pen.* The contour pen (fig. 47), also called the curve pen, is an instrument similar to a ruling pen with curved nibs and a swiveling barrel. It is used for drawing irregularly curved lines such as contour lines and shore lines. The swivel barrel allows the draftsman to change direction of movement with a slight lateral pressure. The contour pen is used free-hand and never with a straightedge. It is sharpened in the same manner as a ruling pen. When using, hold the shaft of the pen perpendicular to the drawing surface at all times to permit a free swivel action. For guidance, see figure 48.

(16) *Road pen.* The road pen (fig. 47) is a swivel instrument similar to the contour pen. The road pen has two sets of nibs. Each set is adjustable for line weight, and the two sets can be adjusted with respect to each other to vary the width of the road casing described by the pen. The instrument enables the draftsman to maintain an exact road width by tracing the whole road casing in one motion.

(17) *Railroad pen.* The railroad pen (fig. 47) is very much like the road pen. It has two sets of nibs but has no swivel arrangements. Its purpose is the same as the road pen—to draw

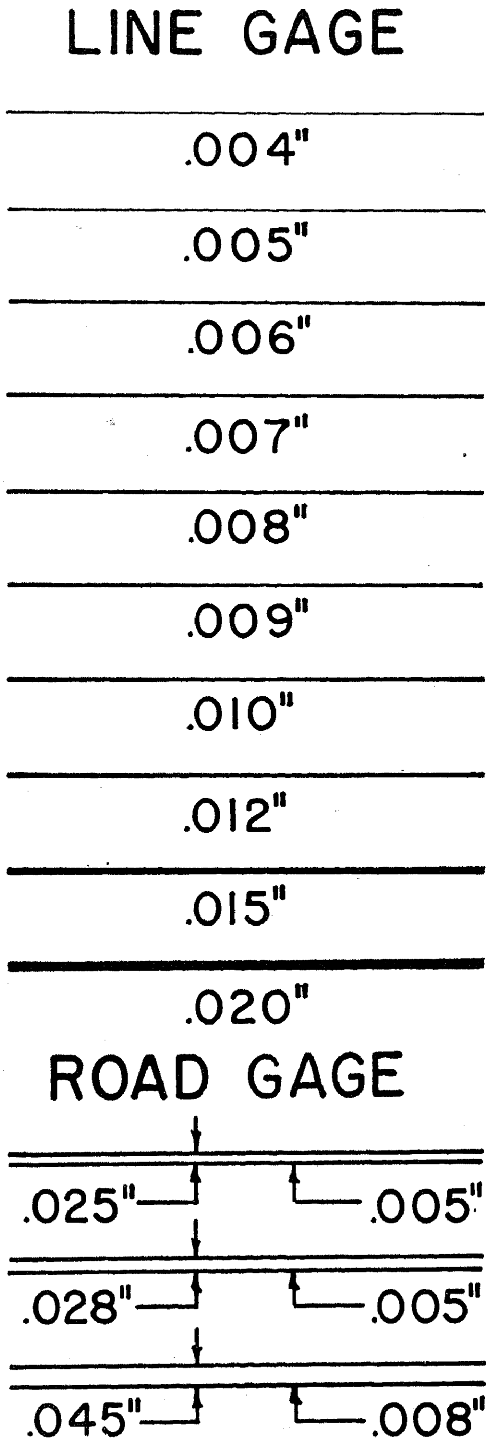


Figure 46. Line gage.

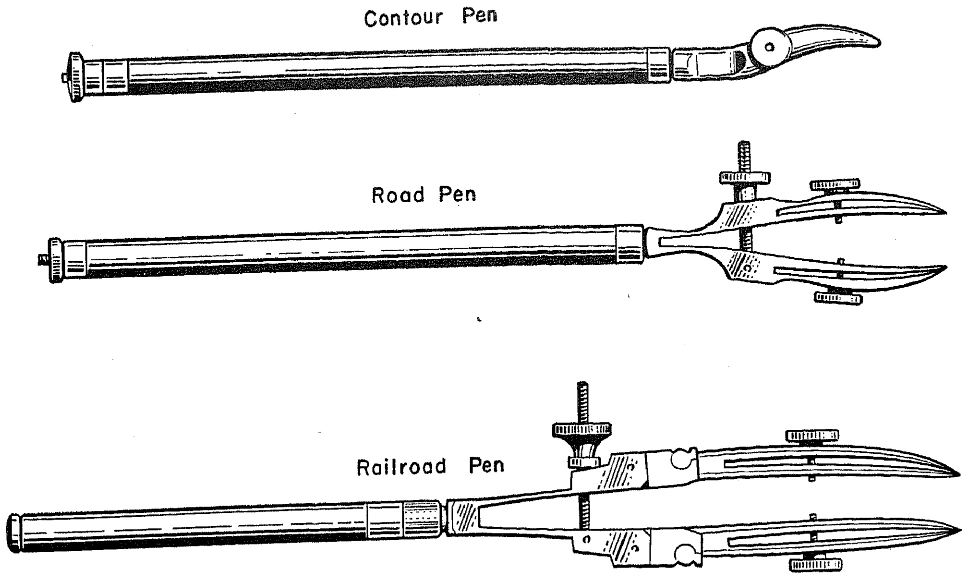


Figure 47. Drawing pens.

two tracks of railway, maintaining exact line weight and track spacing, in a single motion. Where the road pen and contour pen are always used freehand, the railroad pen normally can be used with a straightedge and, therefore, need not swivel, since most railways are based on long tangents.

(18) *Care of drawing pens.* The contour, road, and railroad pens are delicate instruments and should be treated as such. They should be cleaned of *all* ink before being put away, and should have frequent cleanings throughout the day, preferably directly after use. In cleaning these instruments, care should be taken not to mar or scratch them. A knife, razor blade, or paper clip should never be used. The instruments should be cleaned with standard commercial pen cleaner. Place the instrument, point down, in the bottle of the pen cleaner. Let the instrument soak and then wash the excess pen cleaner from the nibs with cold water. Next, dry the instrument thoroughly. When putting the contour, road, or railroad pen away, be certain to release the tension on the instrument by loosening the various thumb screws. In addition, these pens should be taken apart frequently to insure that the swivel section is clean. If there is ink within the swivel section, it should be removed with a standard pen cleaner. If there is no case for any of these pieces of equipment, they should be carefully wrapped in cloth and stored so that there will be no pressure which might break them.

c. Line Construction.

(1) *Uses.* In topographic drafting it is necessary to ink curved as well as straight lines on the blueline boards, often without mechanical guides. With practice, lines of uniform composition can be drawn with the use of the crowquill pen or the contour instruments. Figure 49 shows a culture and contour sample plate which has been drawn entirely with a crowquill pen.

(2) *Use of the crowquill pen in drawing culture.* Before inking any part of the drawing with the crowquill pen, the paper should be burnished (polished by pressing) with a bone burnisher or glass burnisher to prevent loose fibers from adhering to the pen. Plastic burnishers should not be used as they discolor the paper. The tip of the pen is filled from the special ink bottle with one-eighth inch of ink. In

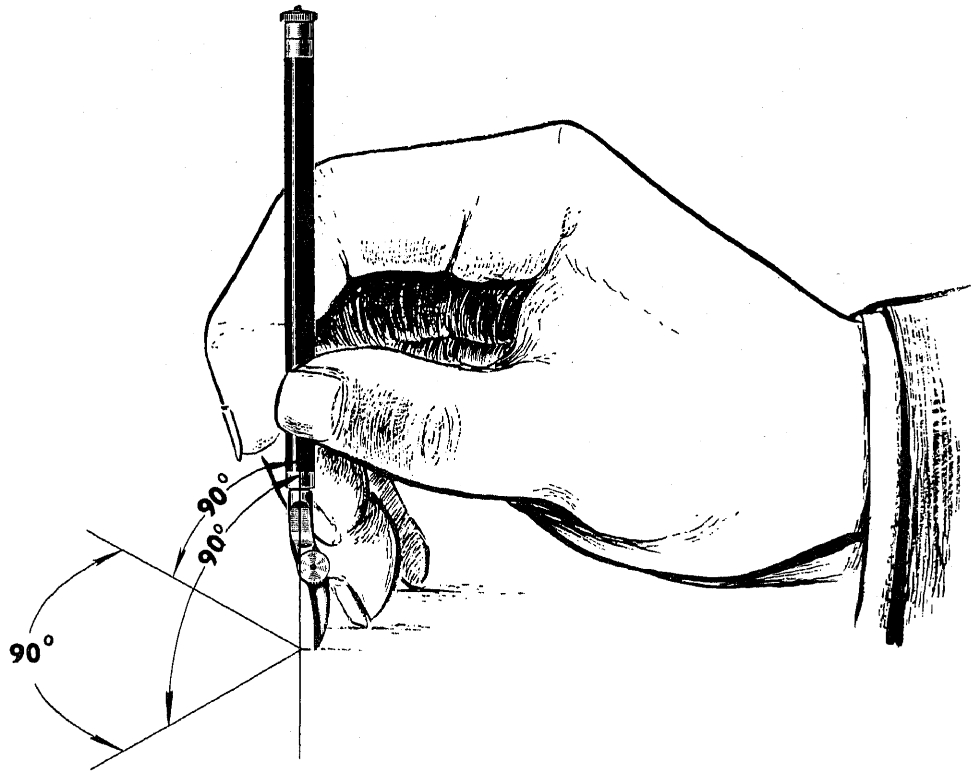
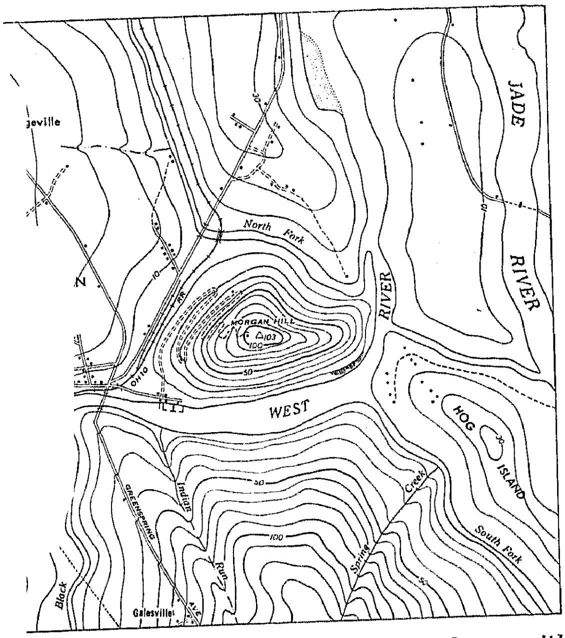


Figure 48. Using the contour pen.



ure 49. Culture details and contour lines drawn with a crowquill pen.

applying the ink to the paper, the pen should merely rest on the paper and be guided by the hand in producing short strokes about one-half inch long. These strokes are repeated until the line is fully opaque. Do not use pressure to force the pen into the paper in order to increase the width of the line. The line weight is controlled by the width of the penpoint. When drawing straight lines, a small 4-inch triangle or a round glass dowel can be used to guide the pen. As the lines are extended, they should be continuously checked with the line gage as to width. When drawing buildings, draw the outline of the building first. Then fill in the inclosed area with a solid covering of India ink, making sure that every part of the area is opaque. Contour lines are drawn in the same manner as straight lines, using short strokes and a light touch. If the point becomes scratchy or the weight of the line changes too much, the penpoint can be honed down with a hard Arkansas stone.

(3) *Opaqueness of line.* To prepare color separation drawings, all drafting is normally done with a waterproof, black ink which will provide consistently black lines and good reproduction of copy. All ink work must be checked to be sure it is opaque; if it is not, camera copy will not be clear and will require retouching. The drafting media should be protected from dirt during drafting operations, and protected from damage when not in use. Suitable covers should be provided.

(4) *Line weight symbols.* In delineating drafting symbols on color separation copy, the draftsman must adhere as closely as possible to the specified weights and gages. Appendix I lists publications which specify the weights and gages of symbols for maps at different scales.

d. Preparing Papers for Ink Work. When the surface of the paper has been destroyed, it is sometimes necessary to resize the paper before applying any ink. A solution of gum arabic in water or collodion is often used for this purpose. Gum arabic is preferred. A light film of the solution is applied to the surface of the paper with cotton batting and allowed to harden. The paper is then burnished before ink is applied. This sizing procedure should be used only for short-term projects because patchwork sizings may discolor the paper surface after a couple of years or crack the inkwork. Most of the time it is possible to erase incorrect inkwork with an electric eraser in such a way that the surface can be reburnished for use without applying any sizing solution. On good paper, the top surface layer can also be sliced off carefully with a razor blade and the paper reburnished without sizing. Care should be taken to keep the slice within the area covered by the previous inkwork. Lines should not be scraped from the surface because this tends to produce burrs which will clog the pen. Sometimes very fine sandpaper is used to erase blueline images on blueline boards for corrections before applying the ink. Care must be taken not to erase too deeply into the paper. The paper is then burnished before inking. Resizing can be done if necessary.

49. Compilation Separation Method

In the compilation separation method, map information must first be selectively separated,

with each particular type of symbolization inked on a separate plate. Each plate is a color-separated drawing. The drawings are then reduced to publication scale negatives from which the printing plates are made.

50. Master Copy

a. Color separation drawings are true copies of specific portions of a map. Therefore, a master copy of the map may be available for use. Without a master copy, it is impossible to draft color separation drawings. The master copy may be any one of the following:

(1) An original compilation sheet.
(2) A revision drawing.
(3) An existing map.

b. The master copy is commonly referred to as a manuscript by mapping agencies.

51. Color Separation Plates

Drafted color separation plates differ from scribing sheets in that final copy is in positive form; that is, the symbols are drafted in black on a white background. The copy is photographed onto a film or glass plate negative from which the printing plates are made (see TM 5–245). As in scribing, separate plates are needed for each color to be printed, and in some instances, two or more plates are combined in the reproduction stage prior to printing.

52. Culture Plate

a. Symbols. The culture plate (fig. 50) contains most of the features which are man-made, as well as certain marginal information including neatline. Roads are drafted with a road pen, and houses are drafted with a pen point, such as a crowquill pen, or pen type scribing tool. Lettering must be as neat and uniform as possible within limits of the time available. Dimensions listed must be strictly adhered to. A line and road gage is provided (fig. 46) to aid in precise setting of line widths; it must be compared with trial lines drawn on scrap material of the same type until the prescribed width is attained. More important than exact line widths is that all lines of one type must be *uniform* in width along their entire lengths.

b. Marginal Data. The marginal data are drafted and stuck up in accordance with a style sheet guide. The neatline is included on this drawing.

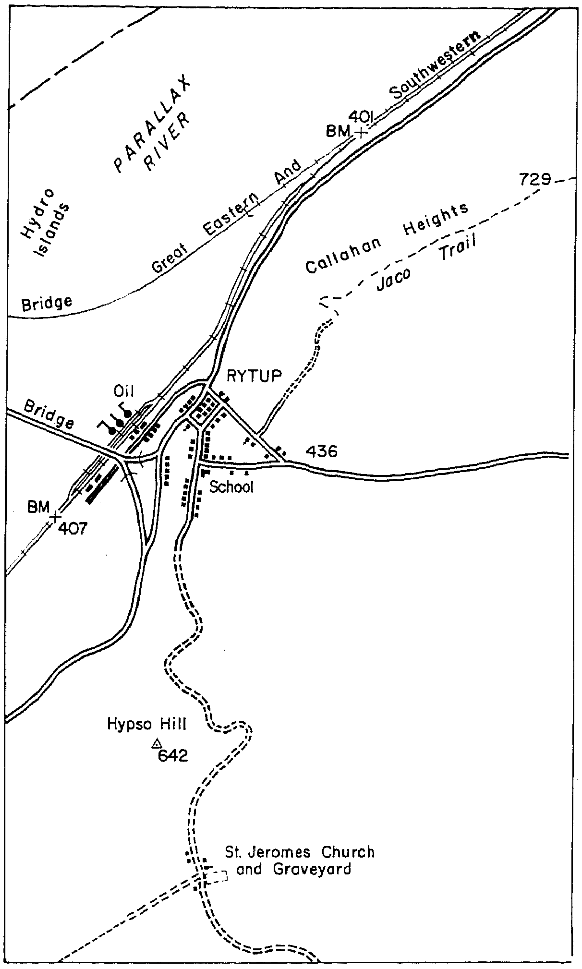


Figure 50. Culture plate.

c. Lettering. Names printed on stick-up may be put on the culture drawing or on a separate overlay.

53. Grid Plate

a. Major Grid.

(1) The major grid (fig. 51) for 1:100,000 and larger-scale sheets is indicated by solid lines at 1,000-unit intervals.
(2) Every 10,000-unit grid line is accentuated in weight.
(3) Where a grid line coincides with a neatline on the map, the grid line is omitted, but the values of the omitted grid line appear on the grid plate.
(4) The Universal Transverse Mercator and the Universal Polar Stereographic grids are shown in black. The color may vary for various foreign grids and would not appear on this plate.

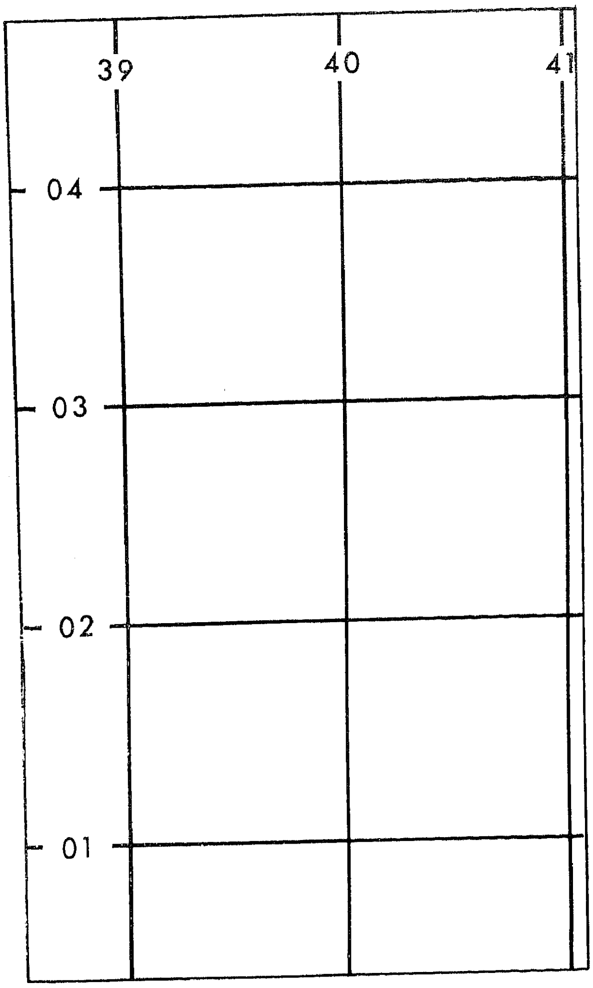


Figure 51. Grid plate.

(5) The grid will be identified by a note in the lower margin of the sheet. The note is printed in the same color as the values for the grid, and will appear on the grid drawing.

(6) See TM 5–241–1 for detailed specifications of grids on maps.

b. Secondary (Obsolete) Grids.

(1) Areas covered by the UTM or UPS grids were formerly covered by grids now obsolete for military use. The obsolete grid is shown as the secondary grid only when required by cooperative mapping arrangements. This is a temporary procedure to provide a common grid system on companion maps of different scales. Secondary grids will be deleted after all maps for a given area have the UTM or UPS grid as the major grid and all geodetic control and other mapping data have been converted to UTM grid coordinates.

(2) The secondary grid is shown by inside ticks emanating from the neatline in their correct declination, normally printed in black, and spaced at 1,000-unit intervals. The 10,000-unit ticks are accentuated in weight (fig. 52).

(3) The values of the secondary grid are normally printed in brown, or some other color not conflicting with the grid color separation plate.

54. Relief Plate

a. Introduction. The relief drawing (fig. 53) normally contains all items which are to be printed in *brown.* Items pertaining to the secondary grid may or may not appear on this drawing.

b. Contours.

(1) It is essential to maintain consistently the prescribed weights of lines for index and intermediate contours.

(2) It is good practice to draft the index contours completely before drafting intermediate and supplementary contours.

(3) In areas of steep slope, the compilation will usually show only the index contours. In such cases, intermediate contours are added only to the extent that index contours will *reproduce in the clear,* without danger of the intermediates running together and filling as a brown mass when printed. All intermediate contours need not be drafted; there may be 4, 3, 2, 1 or no intermediates shown. The number to be dropped will depend upon the amount of space between index contours. There must never be less than 0.005 inch clear space between lines; otherwise, the lines will *plug up* in printing. At the point of dropping an intermediate contour, there must be a clean break—the lines must not be allowed to run together. The remaining intermediate contours that are to be inked in the band should then be

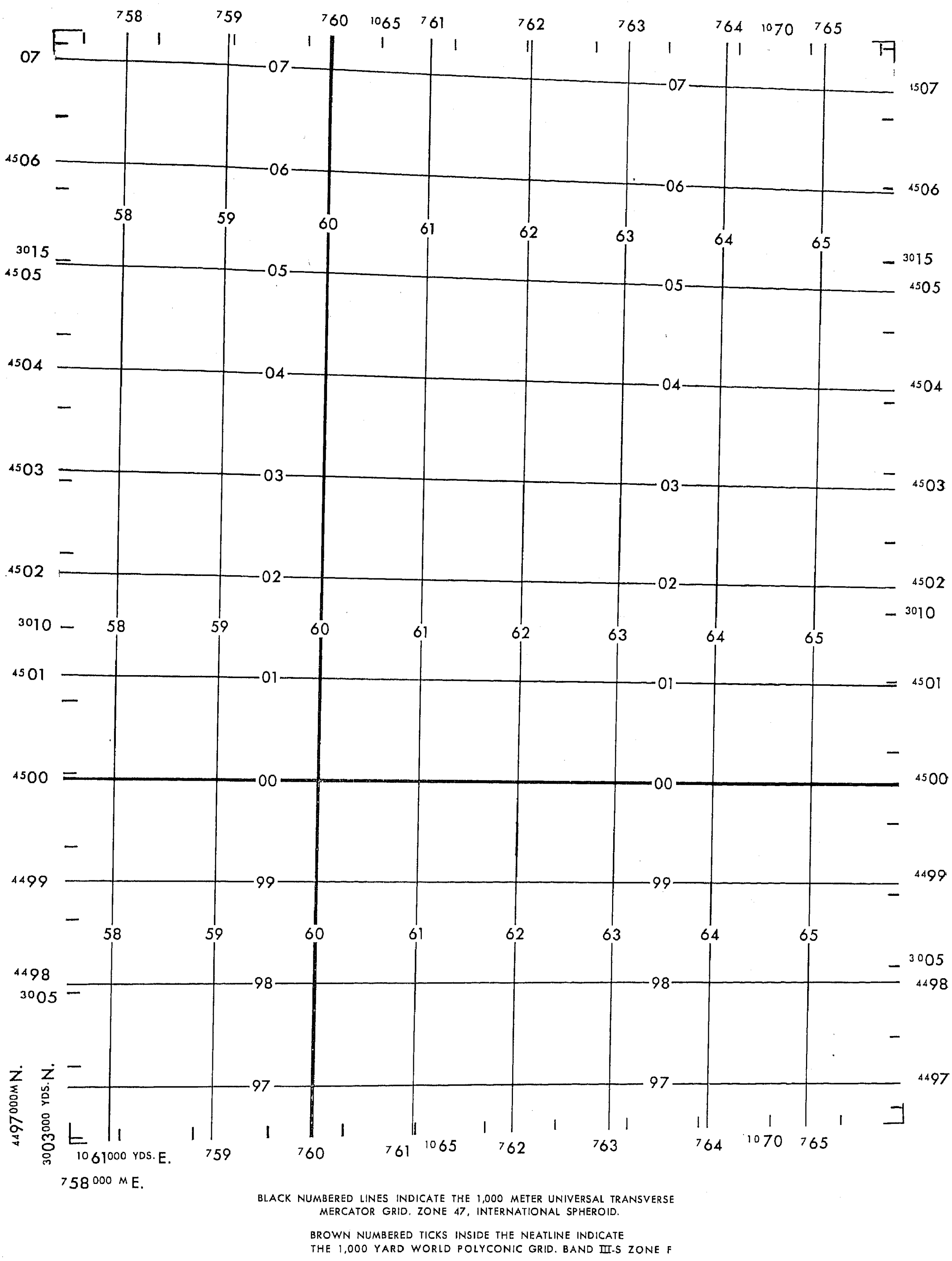


Figure 52. Major and secondary (obsolete) grids shown on a large-scale map.

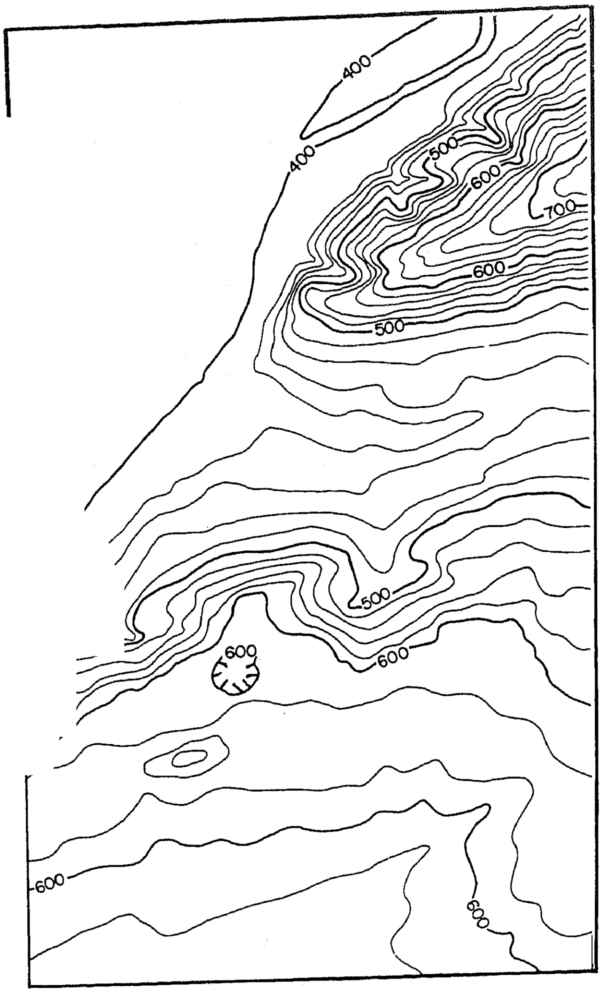


Figure 53. Relief plate.

smoothly replaced so as to give the appearance of even spacing between index contours. When interpolating intermediate contours, the draftsman will draft in this order of preference —high intermediate, low intermediate, next to high intermediate, next to low intermediate.

(4) No attempt will be made to add contours where they have been omitted by the compiler on scarps and cliffs, in depressions, along levees, in cuts and fills, in areas of strip mines, tailings, piles, and mine dumps, and along ditches where they have been stopped abruptly.

(5) Where the compilation shows supplementary contours, the draftsman shows them as they are; he must make no attempt to extend them.

(6) If a slight adjustment must be made for registration between a stream and contours, the adjustment is usually made to the contours.

c. Contour Numbers.

(1) Contour numbers must be added in a systematic pattern. Wherever possible, the contour values are added to supplementary contours and will always appear on the index contours. In flat areas, where contours are relatively few and widely spread, the contour values are added to intermediate contours. The values for contours which lie above the datum plane are identified by numbers. Contours which coincide with the datum plane are labeled ZERO, while those falling below the datum plane are labeled with the appropriate number values prefixed with the word MINUS.

(2) The purpose of contour numbers is to facilitate the reading of elevations expressed by contour lines. They must be placed at or near such critical places as the tops of ridges, the ends of spurs, saddles, the bottoms of valleys, wherever there is a noticeable change in slope, and at the sheet edges. Each formation, if possible, should have its own set of contour numbers. This will enable the map user to read any contour without prolonged search for a reference contour figure. On long slopes, the numbers are best placed in a step-like series following the hill slope in an easy, gentle curve. A contour number must not be placed at the extreme end of a contour adjacent to a road, stream, or other linear feature. Contour numbers are normally omitted in the proximity of spot elevations and bench marks. Wherever possible, contour numbers must be added in the vicinity of such features as cliffs, levees, and embankments where intermediate contours are sometimes omitted.

d. Miscellaneous Features. Other features which may appear in brown on a map include earthen dams, the fill in dry or cyclical lakes and streams, crevices, boulders, strip mines

mine dumps, gravel beaches, and distorted areas.

e. Marginal Data. This information is added as indicated in the appropriate style sheet.

55. Hydrography Plate

a. Considerations. With the exception of open-water area tints, the hydrography drawing (fig. 54) must normally contain all items which are to appear in *blue* on the printed map. Items pertaining to an overlapping UTM grid may or may not appear on this drawing.

b. Linear Features. Hydrography falls in a class with the relief in that most of the drafting is done freehand, without the help of an edge against which to rest the pen. The contour pen will usually prove most satisfactory to use, giving smooth lines and even line weights.

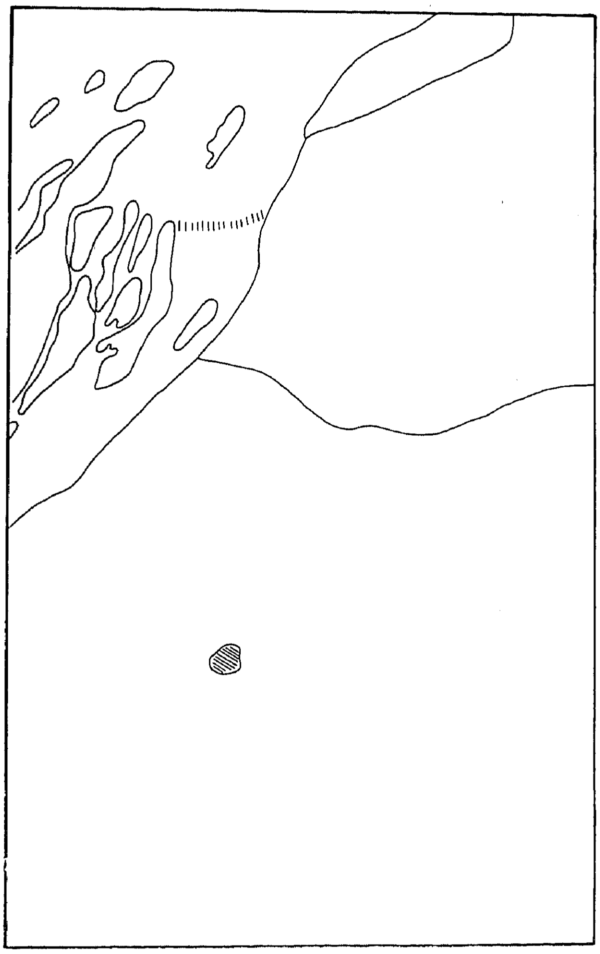


Figure 54. Hydrography plate.

c. Zip-a-Tone.

(1) Zip-a-tone is a commercially produced plastic sheet on which is printed a fine dot, dash, or line pattern. For open-water areas on the hydrography plate, pattern No. 206 is used. It is used only when there are small areas of open water with smooth regular shorelines that can be entirely covered by one 8- by 12-inch sheet. If an open-water area is larger than this, or has an irregular shoreline, and two pieces would have to be joined together to cover an open-water area feature, an alternate method is used. This alternate method is the solid-color fill method described in *d* below.

(2) Zip-a-tone is applied by removing the plastic sheet from its protective paper backing and placing the waxed side down over the open-water areas. It is smoothed down lightly and the pattern cut out by tracing along the shorelines with a sharp instrument. The excess is removed, leaving only the open-water areas covered. The pattern must extend halfway into the line representing the shoreline. A paper shield is then placed over the Zip-a-tone pattern and burnished with a smooth-surfaced instrument to make it adhere firmly to the board. If not properly accomplished, sections may fall off and ruin the copy.

(3) Stic-pat, similar to Zip-a-tone, comes in many designs which are used as various symbols on maps, such as swamp, mangrove, orchard, and mud flats. Uniformity and a great saving of time are realized by their use.

d. Solid Fill for Open-Water Areas. When a map has open-water areas too large to cover by one piece of Zip-a-tone, one of the following methods is used for the open water. The first method is preferred by most users.

(1) In the first method, there is not much work for the draftsman. A composite print, a monochrome printed in a light gray—in this case, a combination of the culture and drainage—is made. All areas of open water are shaded with a blue pencil. Large areas which

take up one-fifth or more of the sheet need be shaded only around the shorelines. This guide is then sent to reproduction where the actual open-water plate is made by photomechanical methods. Since the composite is the only guide followed in reproduction, be sure that all small lakes, which are sometimes mistaken for contours, are shaded. In shading the composite, be careful to *omit* the shading for highway bridges; double-line breakwaters, dams, wharves, and piers; and aqueduct tunnels.

(2) In the second method, a separate blueline board is made for the open water. The method of drafting this plate is similar to the method of drafting the vegetation plate. First, all open-water areas are outlined, using a contour pen or a Speedball pen, being careful to follow the blueline as accurately as possible. The areas are then inked in solid black, making sure that no gray spots exist. In scribing, the open-water shorelines are scribed, and the painted coating is removed by scraping within these lines or peeled from peel-coated plastic. When this board is sent to reproduction, it is photographed or contact printed with a halftone screen which produces a dotted pattern similar to Zip-a-tone.

e. Marginal Data.

(1) All symbols in the legend which are printed in blue will appear on the drainage board. Since the contents of the legend vary according to the area that is being mapped, no standard procedure will be followed. The type of legend to be used will be found in the instructions for each individual project.

(2) Although the numbers and declination data for the overlapping UTM grid will usually be placed on a plastic overlay keyed to the grid board, occasionally these numbers are placed on the drainage board. After being placed on the drainage board, an overlay must be made with the numbers outlined on it. This overlay is then placed over all the other boards and a check for overprint is made with the type being shifted accordingly.

56. Vegetation Plate

The area within the outline of the compilation symbol is to be drafted on the vegetation plate (fig. 55) for reproduction on the published map. This can be hand drafted or a prepared pattern can be used.

a. Woods or brushwood may be drafted as solid. This is reproduced on the published map in solid or screened green.

b. When employing the "solid" method, take care not to ink or scribe beyond the compilation outline of the wooded area. This outline must be drawn in first and then the enclosed area is cleared on scribing plates or filled in on drafting boards.

Figure 55. Vegetation plate.

c. The use of a prepared pattern, however, is preferred to hand drafting. Each type of vegetation cover has its own characteristics and is shown by a special symbol on the map. Stic-pat or commercial Zip-a-tone have the appropriate patterns printed on a wax-backed, transparent material. For woods or brushwood, the Stic-pat pattern is No. 206. The procedure for applying Stic-pat is as follows:

(1) The paper backing is removed from the Stic-pat. The Stic-pat is then placed over the general area which is to be symbolized by the required pattern.

(2) A piece of paper is folded into a small square and used to rub over the Stic-pat to hold it initially in place.

(3) Using a sharp knife, razor blade, needle, or other cutting tool, the Stic-pat is cut on the area outline for the woodland. The excess Stic-pat is removed by pulling the sheet gently upward, leaving the woodland area symbolized with the prepared pattern.

(4) A sheet of paper is placed over the Stic-pat and the entire area burnished until enough heat has been created for the wax to melt so that the pattern will adhere permanently to the plate.

d. In cutting prepared patterns, individual symbols should not be cut in half. It is permissible to cut such symbols as mangrove. In very small areas, hand drafted symbols should be used instead of prepared symbols.

e. When the two sheets of Stic-pat are joined, an overlap of one inch is made and an irregular line is cut.

f. Sometimes if film negative is prepared with the appropriate zip pattern over the whole film. A masking sheet (goldenrod) is then cut where the symbols are to appear on the printed sheet. A lithographic plate can now be made with the pattern in the proper places. The film negative can then be reused with another masking sheet to prepare a new plate for a different map.

57. Type Lists

a. The operations section of a mapping unit prescribes the specifications for labeling maps. The field classification party checks and compiles the names for the labels. The compiler prepares the names overlay which will be used by the draftsman. The draftsman prepares the type list order (fig. 56), following map specifications set down by operations and the names overlay prepared by the compiler. The type list order must be complete and accurate, with the copy marked for the size and style of type to be set by the printer. Prepared cuts which are available may be used. The Type List Form (DA 2594–R) will be locally reproduced on 8″ x 10½″ paper.

b. After the type is prepared, the print is set on the designated base. Then, adhesive backing is applied and it is returned to the draftsman to be used as stick-up on the appropriate color separation plates (fig. 57). There are three types of stick-up currently in use.

(1) Zip-a-tone, Stic-pat, and celanese clear have lettering, patterns, or symbols printed on a transparent and translucent plastic base. The base is left clear if it will overlap other symbols which must show through, or is covered with an opaque backing which will delete the background. An adhesive, such as beeswax, is applied to the back. Thus, when grid numbers are placed over the grid lines, the opaque backing covers the line and obviates erasing it. After the stick-up is positioned, it is covered with a paper scrap and burnished. This burnishing, a combination of pressure and friction, removes air bubbles and softens the wax for firm adhesion. Any adhesive which is squeezed out around the edges should be removed.

(2) Gum stock is similar to opaque Zip-a-tone, but is printed on paper with a gum backing. It requires wetting of the gum before applying and once in place cannot be moved easily.

(3) Photo-type is prepared photographically on an emulsion applied to a very thin plastic film that has been mounted on a back up base for ease in handling. The adhesive is placed on the film side. In order to use phototype, it must be separated (stripped) from its base. After it has been separated, it is treated in the same manner as Zip-a-tone for application and burnishing.

TYPE LIST ORDER (TM 5-240)		DATE RECEIVED		AGES
JOB NAME	CLASS	PRODUCTION NO.	PU	AMOUNT OF TYPE REDUCTION
STYLE SHEET	DUE DATE	PREPARED BY		

	COPY	TYPE			COPY	TYPE	
		SIZE	STYLE			SIZE	STYLE

DELIVER TO	DATE	CHECKED AND APPROVED BY:

DA FORM 2594-R, 1 Jul 62

Figure 56. Type list form.

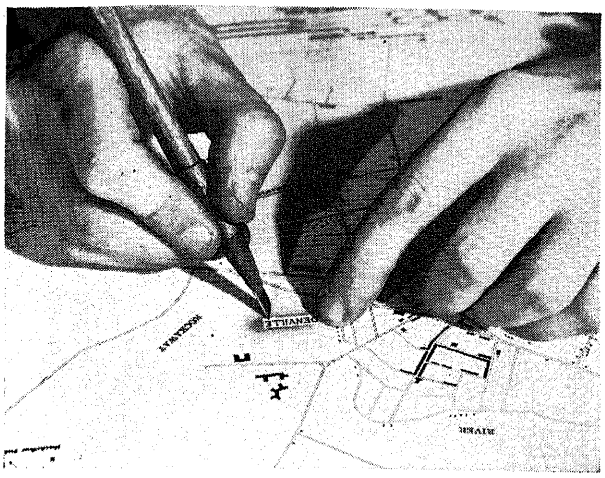


Figure 57. Applying stick-up.

58. Registration Ticks

Registration ticks are drafted on all color separation plates, except the culture which contains the neatline. These ticks are an aid to the pressman in orienting the various color separation plates to the culture plate for proper reproduction. Registration ticks are normally drawn at each corner and center on the neatline. Specifications for the registration ticks are normally found on style sheets.

59. Color Proving

For information on color proving, see TM 5–245.

CHAPTER 5

MAP EDITING

ɩackground

iting is the final phase in map compilation, on, or color separation prior to reproduc- The completeness, appearance, and ac- y of a published map depend to a great t on the quality of map editing. Good nent and a thorough knowledge of the lards of map accuracy, specifications, and ıiling methods of map compilation and re- n are essential to successful editing. The r should have a broad acquaintance with iously published maps of all types, scales, purposes, and should be familiar with a variety of source and reference materials. :he responsibility of the editor to maintain uality control of the final product.

61. Scope and Responsibilities

a. Operations. Map editing includes a comprehensive edit and review of all maps prepared for publication to assure their compliance with accuracy standards and specifications. All project specifications, technical instructions, source materials (source maps, photographs, control data), intelligence reports, and other appropriate reference materials pertaining to the mapping project are studied in order to become familiar with the overall aspects of the project. It is the editor's responsibility to see that all detail contained in the map is correct and that no errors or inconsistencies are present.

b. Types of Edit. Maps must be checked periodically throughout the cartographic process and edited before publication to assure that the information presented is accurate and complete and conforms to accepted standards with regard to the final product desired. Thus, to maintain a quality control of the final product, the editor performs these types of edit prior to publication:

(1) Compilation edit.
(2) Color-separation edit.
(3) Printing edit.

It can be readily seen that much of the material is edited more than once; that each edit provides a double check and is additional security for maximum accuracy of the final product. Each editor may develop his own system for editing a map, but each will utilize the same style sheets, specifications, and special instructions that are pertinent to the specific mapping to make certain that he has not overlooked any phase of editing (see app. V). The necessary corrections and revisions are color coded on a transparent overlay keyed to the compilation or a composite color proof of the color-separated drawings. These corrections are referenced by leader lines to notes in the margin when explanations are necessary. Figure 58 illustrates the method of indicating corrections, while figure 59 is the sample correction code which will be used.

62. Edit Procedures

The procedures used in editing are the prerogative of the individual editor, but it is essential that all items be inspected. Since the density and arrangement of the information shown on a map affect its clarity or readability, the editor must eliminate unnecessary detail and resolve all inconsistencies within the compilation and, at the same time, must adhere to

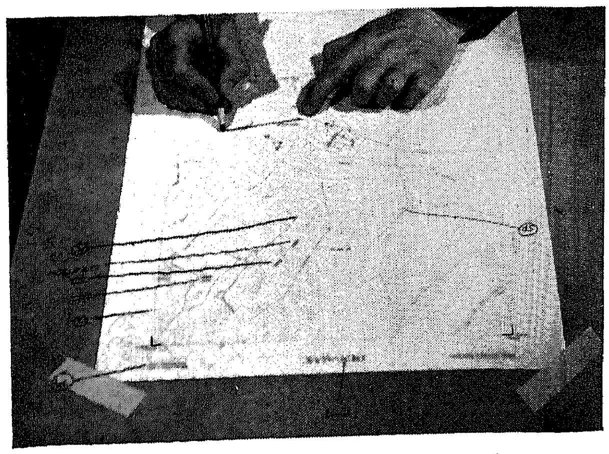


Figure 58. Edit correction overlay.

A	ADD
D	REMOVE OR DELETE
C	CONNECT
X	EXTEND
M	MOVE
R	RESTORE
S	SHARPEN
AD	ADJUST
RV	REVISE
ST	STRENGTHEN
CL	CLEAN
AL	ALIGN
CG	CHANGE
√	AS SHOWN
√/	AS INDICATED
1	BLACK
2	DK BLUE
3	LT BLUE
4	GREEN
5	RED
6	BROWN
7	GRID COLOR

SP	SPELL OUT OR SPELL CORRECTLY
WF	WRONG FONT
LC	LOWER CASE
	MOVE TO LEFT
	MOVE TO RIGHT
	RAISE
	LOWER
	REMOVE LETTER AND CLOSE
	LESS SPACE
	MORE SPACE
	REVERSE
#	SPACE EVENLY
≡	STRAIGHTEN
∧,	INSERT COMMA
·	ADD PERIOD
:	ADD COLON
;	ADD SEMICOLON
'	ADD APOSTROPHE
"	ADD QUOTATION MARKS
—	ADD HYPHEN
[/]	ADD BRACKETS
(/)	ADD PARENTHESIS
═	CAPS (UNDER LETTER OR WORD)

OTHER COLORS WILL BE WRITTEN OUT

CIRCLED NUMBERS "5" INDICATE NUMBER OF INDIVIDUAL CORRECTIONS TO BE MADE

Figure 59. Sample symbol correction code.

specified standards. The compilation edit is more fully covered here, since it is the first formal edit and the quality of the published map depends greatly upon its effectiveness. All further edits are based upon the final edited compilation; therefore, the first edit must be comprehensive and detailed.

a. Compilation Edit. This edit is made after the final compilation is completed. The editor s the base compilation (in manuscript r paneled on a board or a contact print) e necessary overlays (road classification, vegetation, and major drainage) at- The editor first studies and analyzes ecifications, technical instructions, erials, and other appropriate his- geographic reference materials to imself with the particular mapping the end product. He then makes a dit of the compilation, including all ollowing items:

(1) *Projection and grid.* All projection corners and interior projection intersections are checked for accuracy in plotting and values. Grid accuracy and values and any overlapping grids are checked. All map projections and grids must plot within 0.13 mm.

(2) *Control data.* The editor checks the plotting of all horizontal and vertical control used to construct the map, checks the density of the control to be shown on the final map, and verifies that planimetric features and topography are positioned in accordance with the horizontal and vertical control. The plotted position of any horizontal control point shall not be in error by more than 0.13 mm when referred to the map projection.

(3) *Marginal data.* Using the standard style sheets and information provided in specifications and technical instructions, the editor reviews all marginal data for accuracy, placement, and factual information. Special notes to the draftsman are added when necessary. Declination data, credit note, road and railroad objectives, and the boundary, adjoining sheets, and coverage diagrams are checked or added during this phase.

(4) *Mapped features.* The editor makes a detailed review of the cultural, hypsographic, and hydrographic features to assure that all data contained in the compilation are correct and in accordance with basic specifications and symbolization. He evaluates the adequacy of selection, interpretation, density, alinement, classification and generalization of all detail. A careful analysis is made of the portrayal of hypsography, hydrography, and culture; the relationship of vegetation to drainage and cultural features; the selection, placement, and spelling of place and feature names. All overlays are checked for registration to base, proper legends, and correct use of color code or underlining code. The specific items to be inspected are as follows:

(*a*) Roads and related features.
(*b*) Railroads and related features.
(*c*) Features related to communications.
(*d*) Buildings and populated places.
(*e*) Industrial and public works.
(*f*) Boundaries.
(*g*) Hypsography.
(*h*) Hydrography.
(*i*) Vegetation.
(*j*) Names.

All adjoining sheets are tied and road objectives and distances checked.

(5) *Criticism.* The editor also points out corrective measures and general instructive criticisms to aid in the preparation of future manuscripts.

(6) *Review.* The corrected compilation is reviewed to insure that the sheet is cartographically acceptable and ready for color-separation drafting.

b. Color-Separation Edit. After the compilation has been inked or engraved, an edit is performed to insure that color-separated material agrees with the final compilation. The items to be checked are the same as in a compilation edit, but with the emphasis placed on proper symbolization of features, adherence to line weights and symbol measurements, correct size, style, and placement of type, and registration of all color-separated materials. By visual

comparison with the compilation and related material, the editor verifies the accuracy, completeness, quality, and application of appropriate specifications to drafted detail regarding symbolization and proper separation necessary for reproduction. All tint guides or drawings (road fills, built-up area tings, boundary overprints, open water tints, and elevation tints) are checked to make certain they are accurate and complete. This edit is performed on composite proofs.

c. Final Review. This consists of reviewing the culture, relief, drainage, vegetation, grid, type, and tint drawings or negatives to insure that all corrections indicated during the color-separation edit have been made and that the negatives are accurate, properly registered, and are of reproduction quality.

d. Printing Edit. The first three copies run off the press are reviewed by the editors for a final check before distribution of the printed maps. Within twenty-four hours, the reproduction element is notified of any necessary corrections. If corrections are of a minor nature, an errata sheet will be prepared and placed in file with the reproduction negatives for incorporation during future printings. Major changes will be corrected immediately. At times, a color proof may be made and the corrections incorporated to the press run.

(1) *The color proof process.* The separation positives are processed onto a vinylite sheet, using deep-etch principles of platemaking to yield a composite positive image in color.

(2) *An alternate color proof process.* Another process for this procedure is "Watercote," which is available commercially and makes possible the combining of negative separations to yield a composite color proof of negative separations to yield a composite color proof on several surfaces, including Loft-rite and metal-mounted paper.

63. Field Check

When a classification survey (par. 16) has not been performed prior to compilation, a field check survey is often performed before the color separation. The data to be checked are the same as those for a classification survey. When a field check is performed, the editor verifies that all information has been incorporated into the map during the color-separation edit phase.

CHAPTER 6

MAP REVISION

'inition and Responsibility

finition. Map revision is the process of ; a map up to date. It usually consists ction, addition, and/or deletion of map Unless a mapped area has undergone a .ous change, both physical and cultural, no necessity for compiling an entirely p of that area directly from stereoplot- survey information.

sponsibility. Normally, the responsi- ır revision of a map is assigned to the : a topographic unit, who determines revision should be made. His decisions ed upon the reliability of the source ı question; the time available; and the ls, instruments, and specifications given

65. Photo Revision Compilation for Large-Scale Mapping

The method of revising large-scale maps depends upon the type of source material furnished and the extent of the revision. When only a small area of an existing map is to be revised, or revisions over the entire map are minor in nature, the method outlined in *a* through *g* below is used.

a. Sizing the Litho. This operation is performed in order to determine the actual measurement of the original lithographic maps which are to be used as source material for the revision in order to determine what distortion and changes of dimensions are necessary to fit them to the new projection. It is customary to fit the old map inside the new projection to avoid omitting detail. Consequently, the longest side of the old map is scaled to fit the new format.

(1) Place the litho (or whatever material is to be sized) on a flat surface, and measure all four sides. On a sketch of the map (fig. 60), write down the corresponding lengths of the sides on the inside of the border. (Label the TOP ...ent errors in transferring

(2) TM's 5–241–1 through 5–241–9 and 5–241–11 through 5–241–16 contain tables of 5- and 7½-minute intersections for 1: 1, and conversion tables to scale must be used. Figure 61 shows an excerpt from one of these tables, from which data for figure 60 were taken. Using the TM 5–241-series, compute the lengths of the sides of the new maps at the proper scale, and log the results on the sketch outside of the border. (Note that for pen and ink sheets, the sizes taken from the tables for a 1: 20,000 map will result in the drafting size for a 1: 25,000 map.) Scribing is accomplished at reproduction scale, i.e., a map planned for publication at 1: 50,000 scale is scribed at 1: 50,000 scale.

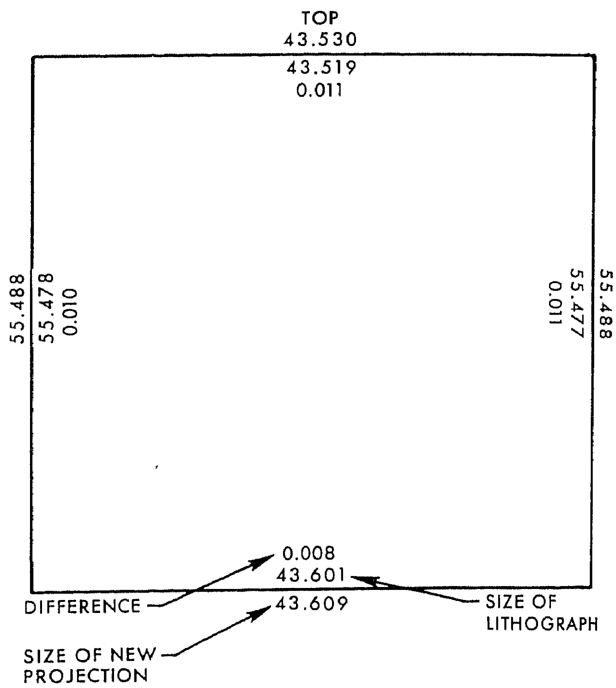


Figure 60. Sizing the lithograph.

LATITUDE 28°00′00″

Δλ	West of C.M. E	East of C.M. E	N
0°00′00″	500,000.0	500,000.0	3,097,030.7
07 30	487,709.4	512,290.6	3,097,037.0
15 00	475,418.9	524,581.1	3,097,055.9
22 30	463,128.2	536,871.8	3,097,087.3
30 00	450,837.4	549,162.6	3,097,131.4
37 30	438,546.6	561,453.4	3,097,188.0
45 00	426,255.5	573,744.5	3,097,257.3
52 30	413,964.3	586,035.7	3,097,339.1
1 00 00	401,672.8	598,327.2	3,097,433.5
07 30	389,381.0	610,619.0	3,097,540.6
15 00	377,089.0	622,911.0	3,097,660.2
22 30	364,796.6	635,203.4	3,097,792.4
30 00	352,503.9	647,496.1	3,097,937.2
37 30	340,210.8	659,789.2	3,098,094.7
45 00	327,917.2	672,082.8	3,098,264.7
52 30	315,623.2	684,376.8	3,098,447.4
2 00 00	303,328.7	696,671.3	3,098,642.6
07 30	291,033.7	708,966.3	3,098,850.5
15 00	278,738.1	721,261.9	3,099,071.0
22 30	266,441.9	733,558.1	3,099,304.1
30 00	254,145.1	745,854.9	3,099,549.9
37 30	241,847.6	758,152.4	3,099,808.2
45 00	229,549.4	770,450.6	3,100,079.2
52 30	217,250.5	782,749.5	3,100,362.9
3 00 00	204,950.9	795,049.1	3,100,659.2
07 30	192,650.4	807,349.6	3,100,968.1
15 00	180,349.2	819,650.8	3,101,289.8
22 30	168,047.0	831,953.0	3,101,624.1
30 00	155,744.0	844,256.0	3,101,971.0

LATITUDE 28°15′00″

Δλ	West of C.M. E	East of C.M. E	N
0°00′00″	500,000.0	500,000.0	3,124,723.9
07 30	487,737.9	512,262.1	3,124,730.2
15 00	475,475.8	524,524.2	3,124,749.2
22 30	463,213.6	536,786.4	3,124,780.9
30 00	450,951.4	549,048.6	3,124,825.2
37 30	438,689.0	561,311.0	3,124,882.2
45 00	426,426.4	573,573.6	3,124,951.8
52 30	414,163.7	585,836.3	3,125,034.1
1 00 00	401,900.7	598,099.3	3,125,129.1
07 30	389,637.4	610,362.6	3,125,236.7
15 00	377,373.9	622,626.1	3,125,357.1
22 30	365,110.0	634,890.0	3,125,490.1
30 00	352,845.8	647,154.2	3,125,635.7
37 30	340,581.2	659,418.8	3,125,794.1
45 00	328,316.2	671,683.8	3,125,965.1
52 30	316,050.7	683,949.3	3,126,148.9
2 00 00	303,784.7	696,215.3	3,126,345.3
07 30	291,518.2	708,481.8	3,126,554.4
15 00	279,251.2	720,748.8	3,126,776.2
22 30	266,983.6	733,016.4	3,127,010.6
30 00	254,715.3	745,284.7	3,127,257.8
37 30	242,446.5	757,553.5	3,127,517.7
45 00	230,176.9	769,823.1	3,127,790.3
52 30	217,906.6	782,093.4	3,128,075.6
3 00 00	205,635.6	794,364.4	3,128,373.6
07 30	193,363.8	806,636.2	3,128,684.4
15 00	181,091.1	818,908.9	3,129,007.9
22 30	168,817.7	831,182.3	3,129,344.2
30 00	156,543.3	843,456.7	3,129,693.1

LATITUDE 28°07′30″

Δλ	West of C.M. E	East of C.M. E	N
0°00′00″	500,000.0	500,000.0	3,110,877.2
07 30	487,723.7	512,276.3	3,110,883.5
15 00	475,447.3	524,552.7	3,110,902.4
22 30	463,170.8	536,829.2	3,110,934.0
30 00	450,894.3	549,105.7	3,110,978.2
37 30	438,617.6	561,382.4	3,111,035.0
45 00	426,340.8	573,659.2	3,111,104.4
52 30	414,063.8	585,936.2	3,111,186.5
1 00 00	401,786.5	598,213.5	3,111,281.2
07 30	389,509.0	610,491.0	3,111,388.5
15 00	377,231.2	622,768.8	3,111,508.5
22 30	364,953.0	635,047.0	3,111,641.1
30 00	352,674.5	647,325.5	3,111,786.4
37 30	340,395.6	659,604.4	3,111,944.3
45 00	328,116.3	671,883.7	3,112,114.8
52 30	315,836.5	684,163.5	3,112,298.0
2 00 00	303,556.3	696,443.7	3,112,493.8
07 30	291,275.5	708,724.5	3,112,702.3
15 00	278,994.1	721,005.9	3,112,923.5
22 30	266,712.2	733,287.8	3,113,157.3
30 00	254,429.6	745,570.4	3,113,403.7
37 30	242,146.4	757,853.6	3,113,662.9
45 00	229,862.5	770,137.5	3,113,934.6
52 30	217,577.9	782,422.1	3,114,219.2
3 00 00	205,292.5	794,707.5	3,114,516.3
07 30	193,006.4	806,993.6	3,114,826.2
15 00	180,719.4	819,280.6	3,115,148.8
22 30	168,431.6	831,568.4	3,115,484.0
30 00	156,142.9	843,857.1	3,115,832.0

LATITUDE 28°22′30″

Δλ	West of C.M. E	East of C.M. E	N
0°00′00″	500,000.0	500,000.0	3,138,570.9
07 30	487,752.3	512,247.7	3,138,577.2
15 00	475,504.5	524,495.5	3,138,596.3
22 30	463,256.6	536,743.4	3,138,628.0
30 00	451,008.7	548,991.3	3,138,672.5
37 30	438,760.6	561,239.4	3,138,729.6
45 00	426,512.4	573,487.6	3,138,799.5
52 30	414,264.0	585,736.0	3,138,882.0
1 00 00	402,015.3	597,984.7	3,138,977.2
07 30	389,766.4	610,233.6	3,139,085.2
15 00	377,517.2	622,482.8	3,139,205.9
22 30	365,267.7	634,732.3	3,139,339.3
30 00	353,017.8	646,982.2	3,139,485.4
37 30	340,767.6	659,232.4	3,139,644.2
45 00	328,516.9	671,483.1	3,139,815.7
52 30	316,265.8	683,734.2	3,139,999.9
2 00 00	304,014.2	695,985.8	3,140,196.9
07 30	291,762.0	708,238.0	3,140,406.6
15 00	279,509.4	720,490.6	3,140,629.1
22 30	267,256.1	732,743.9	3,140,864.2
30 00	255,002.2	744,997.8	3,141,112.1
37 30	242,747.7	757,252.3	3,141,372.7
45 00	230,492.5	769,507.5	3,141,646.1
52 30	218,236.6	781,763.4	3,141,932.3
3 00 00	205,980.0	794,020.0	3,142,231.1
07 30	193,722.6	806,277.4	3,142,542.8
15 00	181,464.4	818,535.6	3,142,867.2
22 30	169,205.3	830,794.7	3,143,204.5
30 00	156,945.4	843,054.6	3,143,554.4

GRID COORDINATES FOR 7.5 MINUTE INTERSECTIONS

Figure 61. Example of tables used for sizing the lithograph.

(3) Study the sketch to determine which side is the longest compared with the size of the new map, and obtain a film negative of the lithograph so that the longest side fits the corresponding side of the new map.

b. Construction of Projection. On a grid board for the scale of the new map, plot the sheet lines and projection and the necessary control.

the Negatives to the Projection. ' now cut up into many smaller ;e individual pieces glued to a ucent base placed over the grid the control on the negative fits ntrol on the grid board. In this scale change of the original map to the final map is minimized in ea of the map. From the paneled a film positive is next prepared.

neation of Photography. A photo in- verlay (see TM 5–243) is made indicating iew photography which is to be used in the ision. Individual sheets of translucent base are then taped over each photograph, and all detail traced from the working area of each photo. (Working area is that area bordered by one-half overlap in all directions.) By choosing map control points (3 or 4, preferably all on the same datum plane), the photo tracing is enlarged or reduced to the scale of the compilation.

e. Transferring Revision Information to Film Positive. The tracings are inserted underneath the film positive so that details match. Incorrect detail is deleted by scraping off the emulsion, and new detail is added to the film positive by inking with inks of the proper color.

f. Compiling Overlays. Normally, vegetation, road classification, and names overlays are then compiled from the revised film positive and other source materials, such as road maps, photographs, and intelligence data.

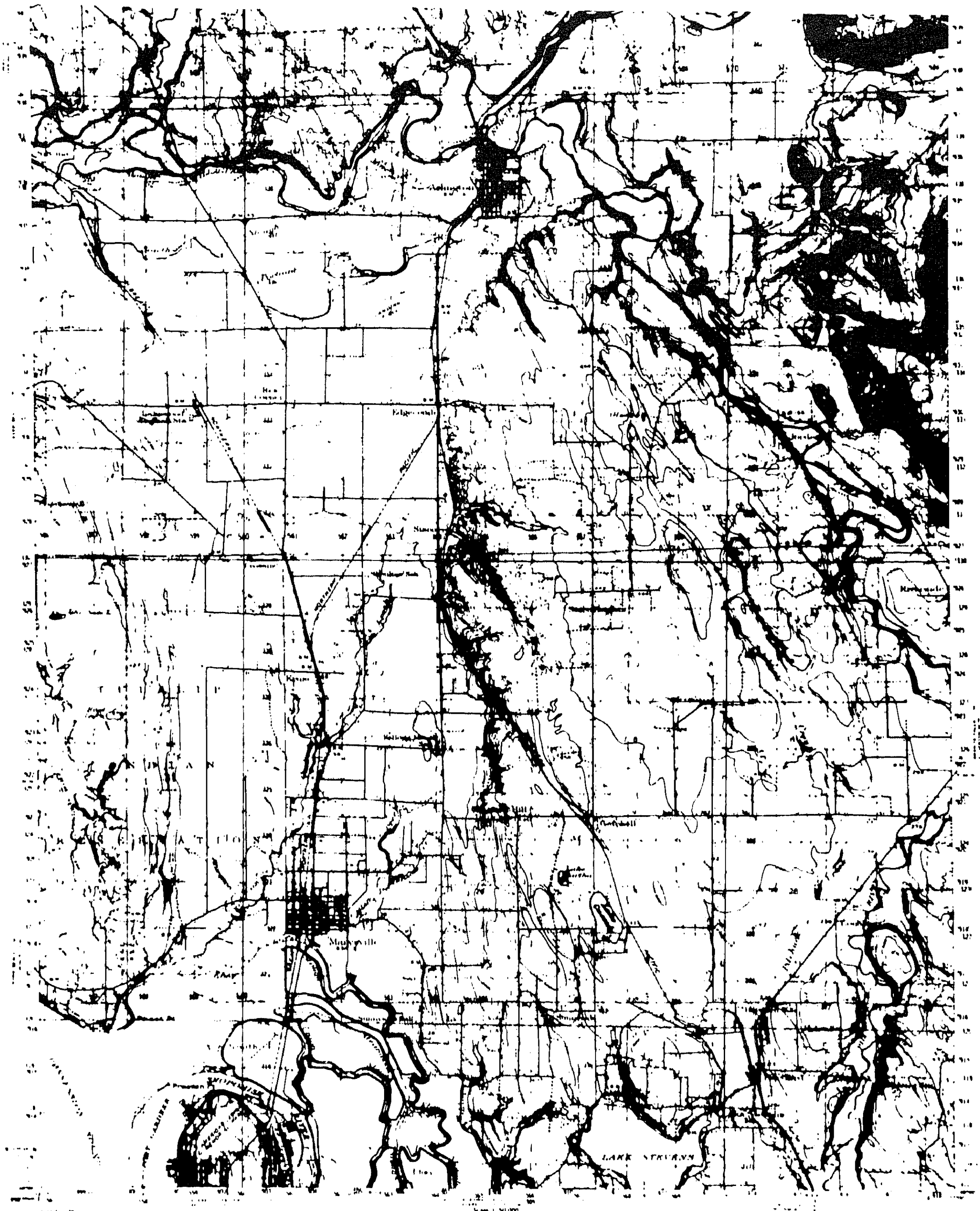
g. Marginal Information and Editing. The revised compilation is completed by pasting on the marginal information in the approximate position it will occupy in the final map. Accurate placement of this information is not necessary except for the dimensions and limits shown in diagrams which the draftsman must reproduce accurately; the draftsman will refer to style sheets when laying out the marginal information. The compilation is then edited, blueline boards prepared and submitted to the drafting section.

66. Alternate Method of Photo Revision Compilation for Large-Scale Mapping

This method is used when an entire map sheet is to be recompiled, and is similar to the method described in paragraph 65. Paragraphs *a* and *b* are the same. In this case, however, a film positive of the original base source material is obtained. The film positive is then cut up and paneled to a sheet of translucent base placed over the grid board. The detail is then retraced in ink on another plastic overlay, using the prescribed symbolization of the new map, and incorporating the photo revisions which are prepared in the same way as in *d* and *e* of paragraph 65. The remaining steps also follow that of paragraph 65.

67. Photo-Revision of Color Separation Material

a. Major Revision. In this case, positives of the color separation material are obtained and combined into one film positive minus the vegetation overlay. Corrections and additions are performed on the combined film positives. When there are a great many revisions, it may be found more economical to redraft the color which is to be revised rather than to correct the positive. The rest of the procedure follows the method described in paragraph 65. A combination of etching and scribing can greatly simplify many map revision jobs. One example would be the revision of the contour negative. This could be accomplished by preparing and exposing a contour film positive to a resist coated scribe sheet and then selectively etching areas that will remain unchanged. If selective etching is undesirable, the areas to be revised may be opaqued out on the contour negative prior to making the film positive. The resist coating is then removed and areas to be revised or changed are scribed with tools in order to complete a finished contour negative suitable for preparing a press plate. Since etching can be done by working on a light table and using a cotton swab, it is a simple matter to etch selected areas of all color separations that are subsequently affected by revisions occurring on related color separations for the same map sheet.



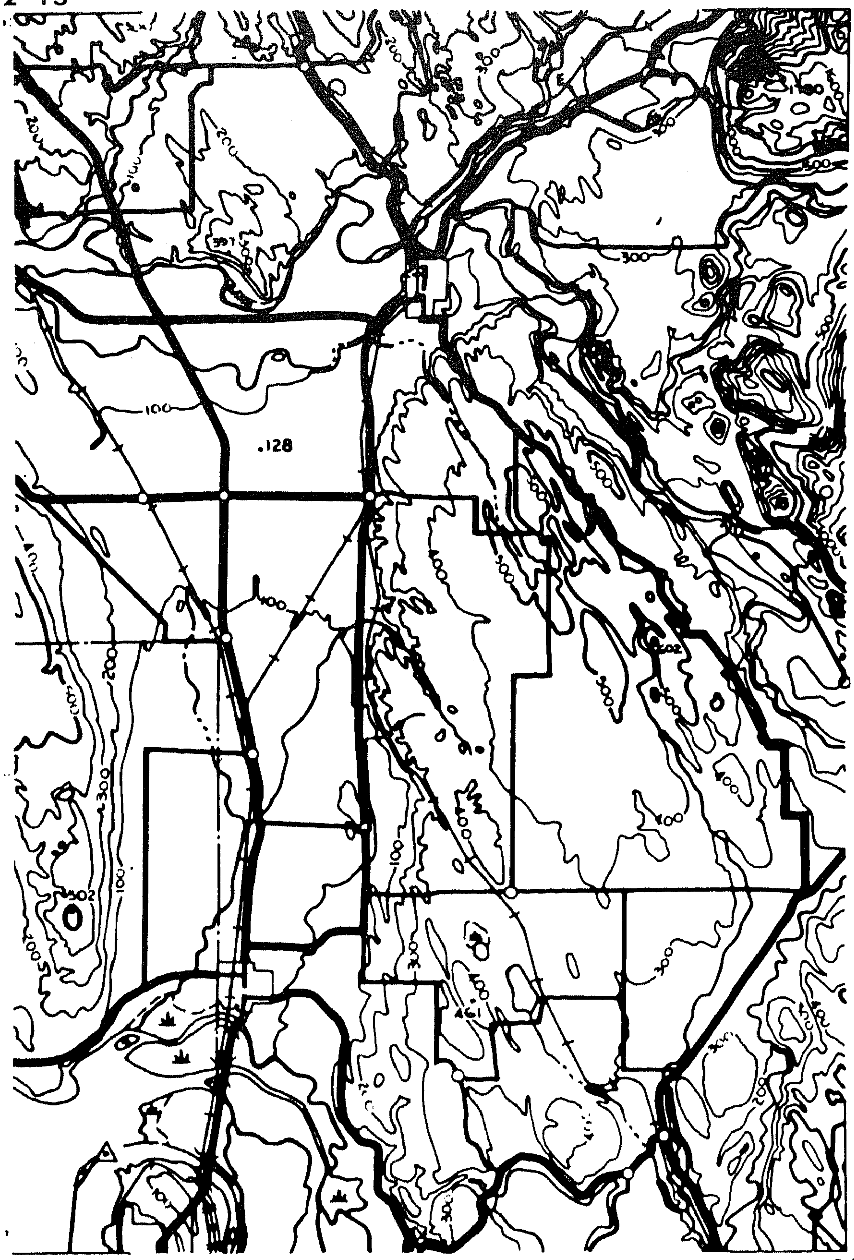
THIS 1:50,000 SCALE MAP HAS BEEN REDUCED TO 1:250,000 SCALE WITHOUT REVISION TO ILLUSTRATE THE NECESSITY FOR PULL-UPS OR THE SELECTION OF MAP DETAIL BEFORE MAKING SUCH REDUCTION.

NOTE CONGESTION OF DETAIL IN THIS EXAMPLE.

Figure 62. Reduction of large-scale map to small-scale without selection of detail.

122°15' TOP 122°00'

48°15' 48°15'



48°00' 48°00'

122°15' 122°00'

1580-11 NM 10-11l

MARYSVILLE, WASH.

111531

THIS 1:50,000 PULL-UP HAS BEEN REDUCED TO A SCALE OF 1:250,000 TO ILLUSTRATE THE DENSITY OF DETAIL THAT IS COMPATABLE WITH A MEDIUM SCALE MAP

NOTE RETENTION OF CHARACTER OF THE MAJOR PLANIMETRIC AND HYPSOGRAPHIC FEATURES.

Figure 63 Reduction of large-scale map to small-scale after selection of detail.

b. Minor Revision. In this case, correction overlays are made directly to the film positive of the color separation material.

68. Compilation of Medium- and Small-Scale Maps (1 : 1,000,000 and Smaller) by the Pull-up Method

a. Considerations. When large-scale maps are considerably reduced in size, the intricate detail of the large-scale map becomes crowded or almost illegible at the smaller scale (fig. 62). It then becomes necessary to select only such detail on the large-scale map as is required for the small-scale map, and to eliminate the remaining detail (fig. 63). A method by which this can be done is known as the pull-up method.

b. Method. Tracings (pull-ups) of selected detail are first made of each source map. Vegetation pull-ups are also made on separate overlays in order not to crowd the detail on the small-scale compilation. Revision from photographs is also incorporated in the pull-ups in the same manner as described in paragraph 65. At the time of tracing, the pull-ups are also checked for match and continuity. After the base projection has been constructed for the new sheet, the pull-ups are sized, photographically reduced, and paneled to the base projection. A clarification overlay is prepared to assist the draftsman in interpretation of the paneled positives. The vegetation overlay is prepared in the same manner, by paneling the positives on a translucent overlay keyed to the base projection. Additional overlays, such as names and road classification are also prepared as described in paragraph 65. After compiling the border data and editing, the maps are ready for color separation drafting.

69. Compilation of Medium- and Small-Scale Maps When Original Maps Will Withstand Reduction

This method is the same as the preceding method except that no pull-ups are prepared. The original maps are sized and photographically reduced to the scale of the new projection. Photo revision detail is added to the map after the entire paneled map has been retraced onto a translucent base overlay.

CHAPTER 7

PHOTOMAPS

Section I. USE

tomaps as Map Supplements

ɔtomaps and Mosaics Defined. A photo- . reproduction of a single photograph or nbly of two or more photographs upon grid lines, marginal data, and place ave been added. A mosaic consists of nore overlapping photographs assem- orm a single picture. The mosaic be- photomap when a grid system, place and marginal information have been

. *Uses.* A photomap or mosaic serves as a ap supplement, and gains importance when a pographic map of the area does not exist or when it is desired to show current conditions or other detail not shown on an existing map. For intelligence studies, the mosaic is adaptable to the study of ground features which cannot be followed out completely on a single photograph. Photomaps are used for reconnaissance, selection of bombing targets, and in operational planning.

c. Advantages. The photomap's chief advantage over the topographic or planimetric map is that it has a wealth of pictorial detail no map can equal. Photomaps can be produced under combat conditions in a relatively short time and with a fair degree of accuracy, as compared to other types of maps. Photomaps made from controlled mosaics can be made in less time than a topographic map. Because there are not many steps in the finishing of a photomap, they are cheap to make. Furthermore, photomaps can be made of an area otherwise inaccessible for either physical or military reasons.

d. Disadvantages. While a wealth of detail is sometimes of great advantage, there are other times when important detail is hidden by less important detail. It takes trained men to interpret intelligently the photomap or mosaic, and good light is required in order to read it. A photomap is inferior to a map, since it shows positions and directions inaccurately unless it is made from controlled mosaics, on which the accuracy of position and direction approaches that of a map made to the same ground control. Further, a photomap does not show relief.

71. Specifications for Photography

Generally the specifications for mosaic photography are similar to those for any mapping from vertical photography. It is desired that the photographs have 60 percent overlap along the flight line, 15 to 30 percent side lap between the flights, and less than 10° of crab. In areas of extensive relief greater side lap is required. The amount of tilt for mosaics is usually more rigidly controlled than normal, and is usually specified as not more than 5° for any one print, or more than 2° for any 10-mile section of flight line, or more than 1° for the entire job. Units usually set their own specifications depending upon the accuracy desired in the finished project. All prints utilized for mosaics must be printed on single-weight glossy paper with a uniform tone maintained throughout the entire set of prints. Ideally suited photography that is specifically designed for controlled photomaps would have a forward overlap of 80 percent and a side lap of 50 percent. This would allow for use of the center portion of the photography which has a minimum of scale change and relief distortion.

Section II. TECHNIQUES FOR LAYING MOSAICS AND PREPARING PHOTOMAPS

72. Military Mosaics

a. Characteristics. Mosaics of aerial photographs are an assemblage of as many aerial photographs as may be required to cover the area concerned. Mosaics are usually assembled to form pictorial representations of an area to

show planimetry only. Elevations are usually not represented, although mosaics may be contoured or formlined if desired.

b. Types of Mosaics. Aerial mosaics are of four general types.

(1) *Strip mosaic.* An assembly of a strip of vertical photographs taken in a single flight.

(2) *Uncontrolled mosaic.* An assembly of two or more overlapping vertical photographs assembled only by matching photographic detail without the aid of ground control. Such a mosaic gives a good pictorial effect on the ground but may contain serious errors of scale and azimuth inherent in the photographs themselves.

(3) *Semicontrolled mosaic.* Is one which is laid to *limited* ground control, augmented by radial line or slotted-templet positions. In both uncontrolled and semicontrolled mosaics, contact prints of the aerial negatives are used.

(4) *Controlled mosaic.* Is one which is laid to ground control, augmented by radial line or slotted-templet positions. It differs from semicontrolled mosaics in that the photographs used are corrected in projection to bring them to the same scale and to restore them to the vertical view by restitution-printing (rectification). This operation insures a degree of accuracy in the controlled mosaic which closely approaches the accuracy of a planimetric line map compiled by radial line methods. The prints used are not straight contact prints; having been projected to ratio then to a common scale, and having undergone restitution to offset the effect of tip, tilt, and swing. The degree of reduction or enlargement necessary and the angle of rectification are determined by the relation of the ground control positions to their apparent positions on the photographs. Although the inherent distortions in the aerial photograph cannot be entirely eliminated even in the most precisely assembled controlled mosaic, they may be lessened to a normal error by proper procedures and techniques. Errors in image position caused by relief of terrain are not removed in a controlled mosaic.

73. Uncontrolled Mosaics

a. Considerations. An uncontrolled mosaic is a compilation of photographs without regard to any horizontal control positions, With perfect photography and low-relief terrain it might be possible to start with a print near the center of the mosaic area and build onto it in successive circles by matching detail. However, an attempt to lay a mosaic of an extended area in this manner will usually result either in a large, obvious mismatch in detail being thrown into one part of the mosaic, or in excessively large and obvious errors in scale and azimuth. Therefore, it is advisable first to lay a set of dry prints over the board, using tape, paper clips, or staples as for an index mosaic, and to adjust the various portions until an apparently correct laydown is obtained.

(1) *Method of tearing.* Holding the print in one hand, use the other hand to tear off the portion to be discarded. Tear with a twisting motion so that the paper is torn back from the edge, leaving the edge of the portion to be used thinner than the remainder of the print.

(2) *Feathering.* Lay the print over a cylinder-shaped block with the emulsion side down. Using fine sandpaper attached to a narrow board, draw it over the torn edges of the print until a feather-edge effect is obtained. In sanding the edge of the print, be sure not to remove too much paper. This makes the edge of the print too thin and causes it to appear darker after it has been laid.

b. Orienting First Photograph. Using a hard-surface, nonporous board, such as masonite, for mounting the prints of the mosaic, locate the center of the board by the use of diagonals. After laying out all the prints in the project, select the print that falls in the center of the laydown. This print will be the first one laid and will be mounted in the center of the board. The rest of the prints will be laid from the center out.

c. Applying Adhesive. Apply gum arabic to

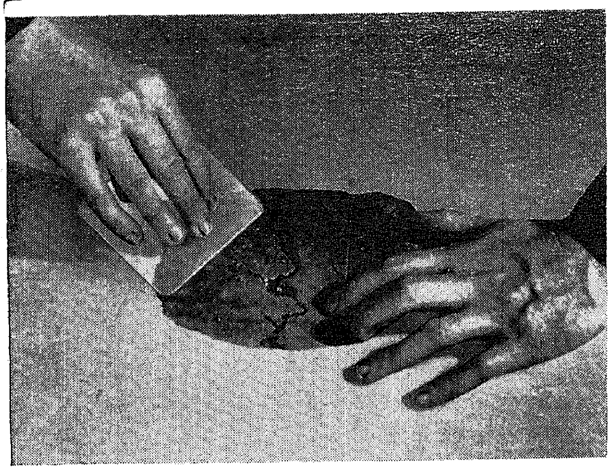


Figure 64. Using plastic squeegee to remove excess adhesive.

the mosaic format board. Then lay the first print approximately in the center of the previously ticked board. Use a plastic squeegee to remove the excess adhesive by working from the center of each photo toward its outer edge (fig. 64).

d. Marking Cut Lines. After the adhesive of the first photo has set, select the next photo to be laid and orient it to the center photo using the detail common to both photos in the overlap area as a guide. Using the flip check method to improve the match, draw a line in grease pencil through the area where the print is to be torn (fig. 65). The emulsion is cut and the photos are torn in a feather edge. Select areas where prints are of identical tone, and avoid straight-line tears except where the tear is parallel to straight roads, railroads, or fence lines.

e. Placing Match Lines. After the photo has been torn along the prescribed line and has been feathered, reorient it in its proper position using the flip-check method. Holding the print in place, use a grease pencil to draw match lines. Starting the line in from the torn edge of the photo, radiate it out from the center of the photo over the torn edge and onto the adjacent photograph. Proceed around the photograph placing match lines at about 50- or 75-mm intervals (fig. 66).

f. Laying Additional Photographs. Apply the adhesive as with the first photograph; then lay the photo using the match lines as a guide. Adjust the photo so that all detail matches as closely as possible to the detail of the adjacent photographs. Squeegee the excess adhesive from the print and wipe clean with a damp sponge or cloth. Use the same procedure for the remaining prints in the project.

g. Stretching Photographs. There are many occasions where the photographs will have to be stretched to obtain the best possible match of detail. A greater degree of stretch may be obtained by immersing the photograph in water and soaking it for a few minutes.

74. Preparation of Photomaps

a. Scope. Accuracy in a semicontrolled mosaic is obtained by holding to the flight line and not necessarily by matching detail perfectly.

b. Controlled and semicontrolled photo mosaics. Controlled and semicontrolled photo mo-

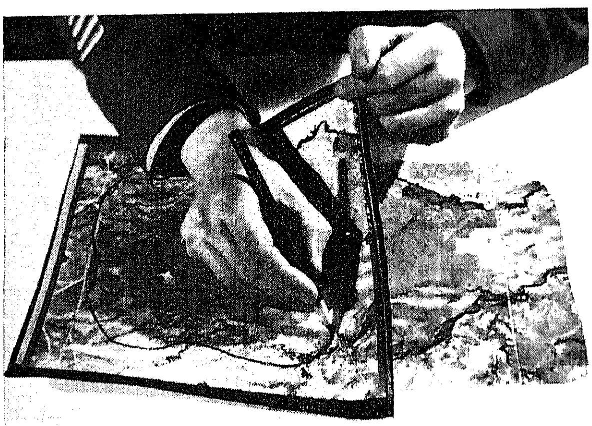


Figure 65. Marking the cut line.

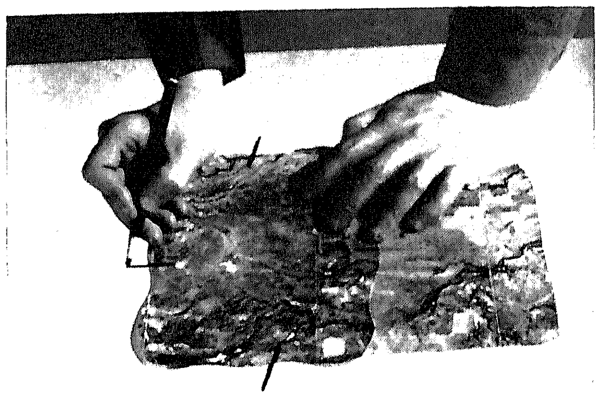


Figure 66. Marking match lines.

saics are normally prepared in the operational sequences outlined below:

(1) Generally, select the center sheet of small projects and prepare it first, thus facilitating progressive work assignments and use of the break-away system of edge matching of detail on adjacent sheets.

(2) Prepare a control overlay for the format board on stable transparent material. This is done by placing the material over the format board and tracing the sheet corners and circling the control points in ink. The radius of the control point circles shall be equal to the horizontal accuracy required for fitting the mosaic to the control.

(3) Prepare the format board for the break-away process as follows:

(*a*) Coat an area approximately 100 mm in width outside of and adjacent to all neatlines of the sheet with floor wax.

(*b*) Place a strip of 75 mm-wide masking tape gummed side down over the waxed area and butted to the neatline.

(*c*) Coat the masking tape with floor wax.

(4) Transfer all control points from the set of control photographs to the rectified or ratioed photographs by pin pricking and then filling the pin pricked hole with wax from a yellow wax pencil.

(5) Prepare the rectified or ratioed photographs for mosaicking by trimming them to the center of the overlap of adjoining photographs. Trimming is done by cutting through the photographic emulsion only and tearing the photograph paper along the cut line. The edge is then sanded to produce a smooth beveled edge on the paper side of the photograph.

(6) Orient one of the prepared photographs to the control points and/or map detail on the format board. Tape the oriented photograph in place on the board and check its position with the control overlay or film positive of the topographic or planimetric map as required. After verification of the photograph's correct orientation, draw two registration marks with a wax pencil on each side of the photograph and onto the format.

(7) After proper registration remove the photograph and coat the back of the photograph and the format board with a gum arabic solution (20° BAUME). Reorient the photograph to the registration marks and press into place. Remove all excess adhesive with a squeegee and recheck for proper orientation. After all photographs are in place, recoat loose edges with gum arabic and flatten into place with a burnishing bone.

(8) Recheck the mosaic with the control overlay or film positive of the map and clean the surface with a suitable solvent.

(9) Remove the overedge portions of mosaic by the break-away method. This is accomplished by cutting through the mosaic along the sheetlines and removing the overedge mosaic and the tape. The overedge strips of mosaic are then separated from the tape, reoriented to the sheetline of the adjacent format board and glued into place.

c. Uncontrolled Photo Mosaic. Uncontrolled photo mosaics are prepared in the operational sequence outlined below:

(1) Select the center flight of aerial photographs to be mosaicked and orient the photographs in the flight one to another by matching photographic detail carefully and fasten together with masking tape. With a grease pencil draw a straight line on the assembled photographs the full length of the flight and as near the center of the flight as possible, then disassemble.

(2) Draw a straight line in pencil on the required number of mosaic boards equal in length to the one on the prints. This line will serve as a base line for controlling the azimuth of the mosaic. Complete the preparation of

the format boards as described in paragraph *b*(3) above.

(3) Trim the individual photographs in the flight as described in *b*(5) above.

(4) Orient the center photograph in the flight by matching the line drawn on the photograph to the one drawn on the format board. Proceed with the mounting of the photograph as described in *b*(6) and (7) above. Succeeding photographs in the flight are oriented to the first one by matching photographic detail and maintaining the azimuth by matching pencil lines as in mounting the first photograph. Photographs in adjacent flights are then oriented to the first flight by matching photographic detail in the overlap area between flights. Each adjacent flight when added to the first flight then becomes the base for the next.

(6) The break-away method described in *b*(9) above is used to insure proper edge matching of detail between format boards. Upon completion the mosaic is inspected and then cleaned with a satisfactory solvent.

d. Completion of Photomaps.

(1) Individual photographs within the mosaic assembly will vary in tone and will require some blending prior to reproduction. Limited tone control is possible by tinting the lighter areas with a transparent blue dye Nutran No. 605. While applying the dye it is necessary that the mosaic be viewed with a magenta filter to determine when sufficient dye has been applied to achieve the desired tone.

(2) The remaining completion work consists of normal cartographic operations as follows:

(*a*) Select interior name and marginal data type from source material and order from the type-servicing element.

(*b*) Prepare an overlay for all marginal data type on stable transparent plastic material about .10 mm thick, press polished on one side only. The material is placed on the format board and the sheet corners are traced in ink onto the overlay. All marginal data type will be affixed to this overlay.

(*c*) Utilizing a film positive grid overlay, prepare an interior geographic names overlay. The overlay is prepared by registering the grid overlay to the format board and tracing the sheet corners in ink onto the overlay. All interior names and descriptive type are then affixed to the overlay in accordance with the specifications and style sheet for the project.

75. Break-Away Method

a. Purpose. The break-away method of mosaiking was designed for use where units of a project must be completed in order of their priority and where time is the prime factor. This method involves the removal of the mosaic strip outside the neatline of one board and its relocation along and inside the neatline of the mosaicking board for the adjacent sheet. The advantages of this method over other methods in use at the present time are as follows:

(1) The possibility of error in transferring border matches from board to board is reduced to a minimum.

(2) It permits the completion of individual sheets in order of their relative importance.

(3) It expedites the completion of a specific project in that, once the first unit has been completed and border match strips have been transferred to adjacent boards, it is then possible to assign one man to each of the new boards.

(4) It has been found to be a definite advantage where negatives of the boards are required for reproduction. The problem of adjusting and fastening the border masks, which must be contended with where an entire project has been mosaicked on one or more large boards, is eliminated.

b. Preparing Small Boards for Breaks. Figure 67 shows the order of mosaicking a series of 8 boards, with arrows indicating the direction of the breaks. It will be noticed that

boards SI and NI can be made at the same time with each board breaking 3 ways.

c. Use of Tape and Wax. The sides of the small boards that break onto other boards will be laid with 50-mm drafting tape. Lay the tape on the outside edge of the neatline extending approximately 50 mm over the ends. Rub a light coat of wax over this tape. The sides of the boards that do not break will be laid with 19-mm drafting tape. On a board that receives a break strip there will be no tape placed on that edge.

d. Use of Acetate Strips. Lay the sides of the small boards that break onto other boards with 100-mm acetate strips. The acetate is laid on the outside edge of the neatline, using rubber cement as an adhesive. The control from adjoining boards which fall under the break strip should be transferred to the acetate strips, thereby giving additional control outside the neatline.

e. Laying Photos on Break Strip. Assemble the mosaic so that coverage is extended beyond the neatlines with the prints or portions of prints falling outside these lines being mounted directly on the break strip. Do not mount any portion of a print outside the limits of the break strip. In some instances only that portion of the print that falls on the break strip is glued, keeping the remaining portion free of glue and free of the board.

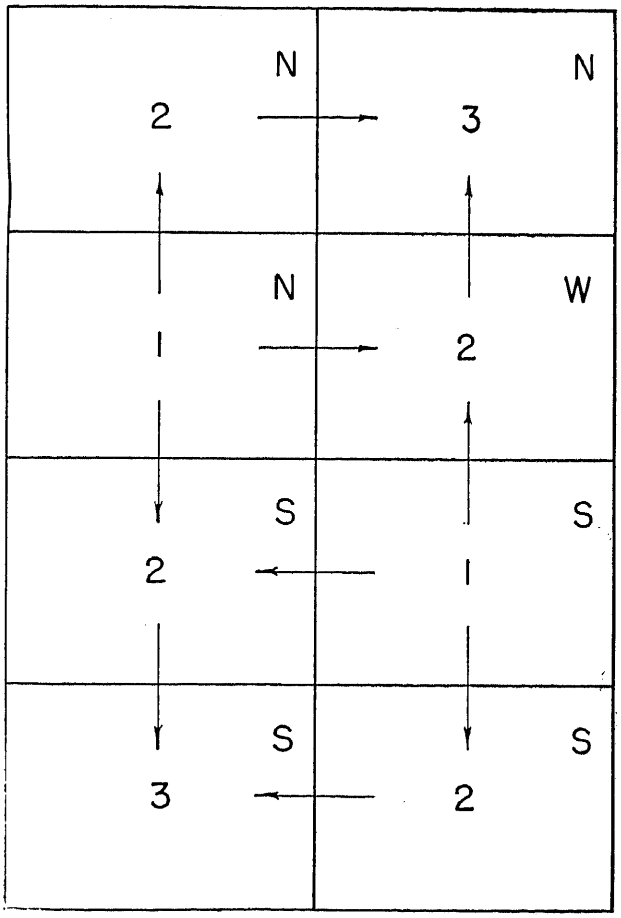


Figure 67. Order of multiple board mosaicking.

Figure 68. Lifting mosaic strip.

f. Cutting and Marking Break Strips. With a sharp razor blade and a straightedge, make a fine cut through the image along the centers of each of the limiting lines of the sheet. Then take up the strips on which the prints are mounted by loosening one end of the strip and gently pulling up the entire strip from the board (fig. 68). Carefully peel the acetate off each strip leaving only the assembly of prints which are held together by the adhesive used in the original mounting (fig. 69). Replace the

Figure 69. Removing tape.

its original position and mark
ule intersections by small ticks
se on the break strip.

rring Break Strip. The position
in is determined on the adjacent
atline, and the adhesive is
eak strip (fig. 70). Start-
r the middle of the strip,
e to keep it to the neat-
s. A break strip will
hen taken off its original
o be stretched when laid
. The best possible match
strip taking care not to
on the break strip side.

saic Board. After all boards
s glue is washed from the
All grease pencil marks can
with benzol or an art gum

Figure 70. Mounting the mosaic strip on the neatline of adjoining board.

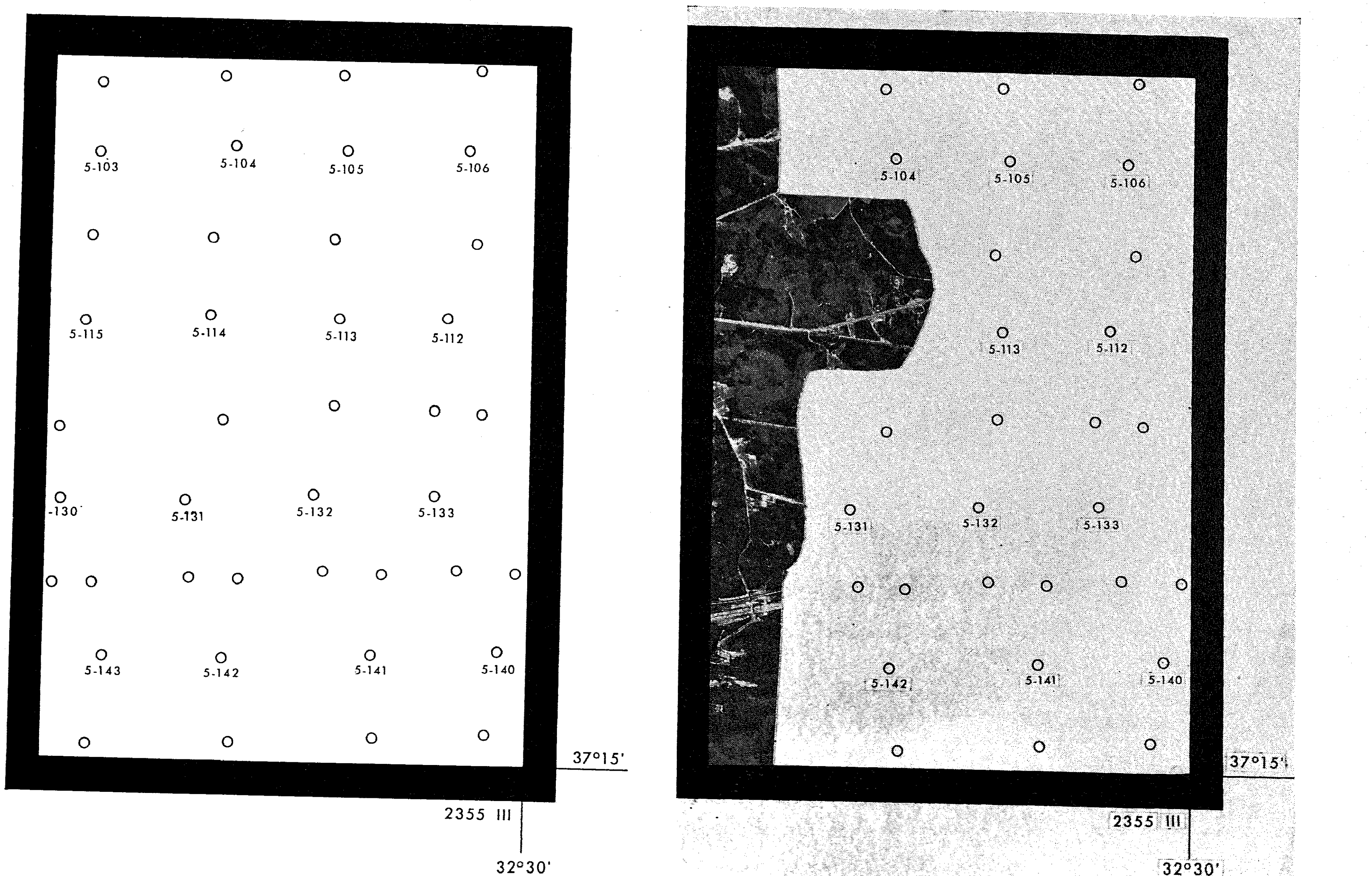
76. Controlled Mosaics

a. Rectification of Aerial Photography. Principal and pass points are first picked on the photos and their geographic location established on the compilation base (fig. 71). Rectified prints are then made to fit this control by the methods described in paragraph 94.

b. Accuracy. Only those points on the compilation base which have been established by the radial-line plot will have the accuracy of that plot. Position errors between these points are caused by relief and will have magnitudes depending upon the amount of that relief. Controlled mosaics to specified accuracies may be laid by proper selection of points for rectification. In terrain having relief, more points are used in the rectification, and several rectifications of the same negative must be made to fit the control in the various portions of the area covered by the print. Mosaics with such refinements will not generally be produced under combat conditions. Therefore, it cannot be expected that mosaics produced under these conditions will have sufficient accuracy in position for use by the artillery in the same way as an accurate topographic map. It is often necessary in such cases for artillery to register in each photo section to obtain accurate fire. It is therefore desirable that the principal point of each photograph and the outline of each photo section be indicated on the mosaic so that proper corrections for relief displacement can be made.

77. Grid Systems

Style sheets prescribe the grid systems to be shown on photo maps. The prescribed grid for controlled and semicontrolled photo maps is the military grid shown in figure 71.

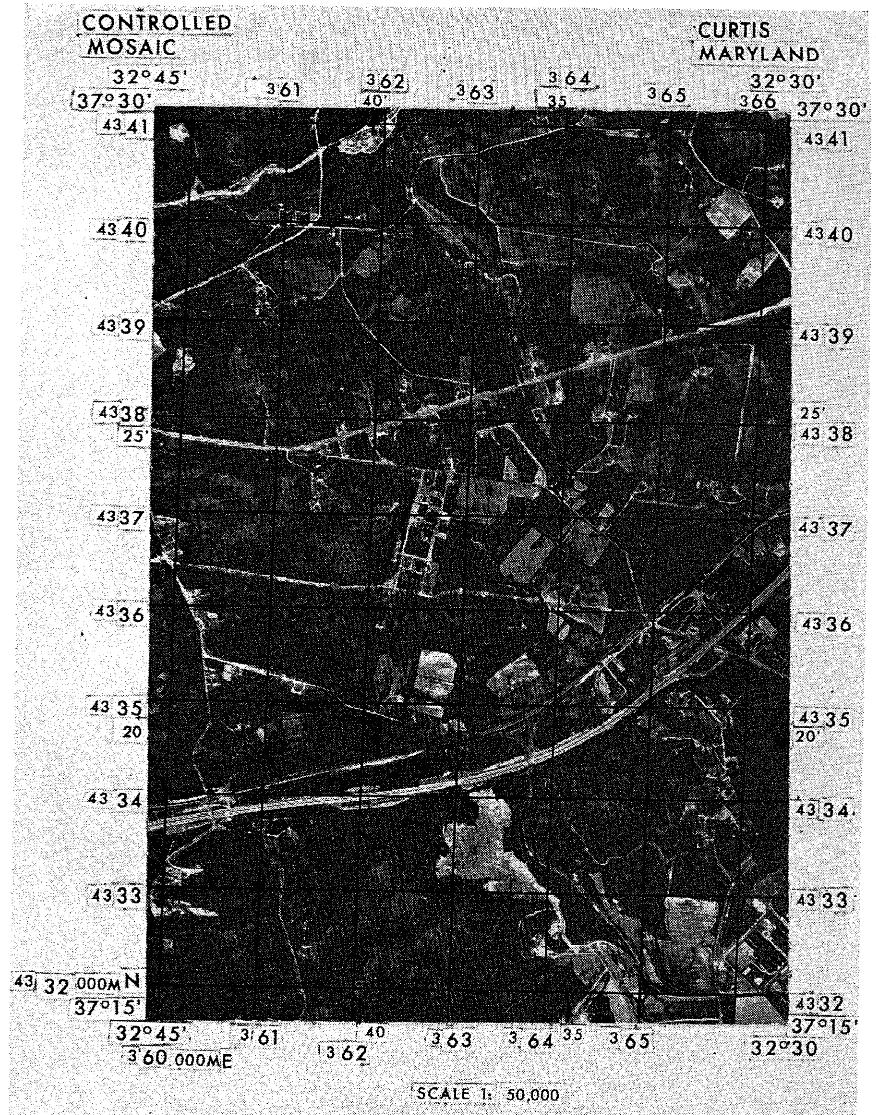


a CONTROL PLOT READY FOR MOSAIC

b BEGINNING ASSEMBLY OF MOSAIC

Figure 71. Controlled mosaic.

c REMOVING BORDER STRIP
FOR TRANSFER TO ADJOINING BOARDS



d PHOTOMAP

Figure 71.—Continued.

CHAPTER 8

EXTENSION AND ADJUSTMENT OF CONTROL

Section I. PROCEDURES

78. Control Points

In compiling maps from photographs it is necessary to orient the photographs with respect to the map base and with respect to each other. This may be done by ties to selected control points of known position and elevation. When these points have been established by field surveys and identified on the photographs in the field, they are known as picture points and are necessary for adjustment of the photographs to the compilation scale and for the determination of auxiliary control by office procedures. Usually these points are not located in sufficient density or proper arrangement to insure adequate control of the photographs to the compilation base. Additional supplemental control points must therefore be selected and marked on the photographs. These photogrammetric control points must have features identifiable on the photographs but they are not surveyed and marked on the ground. Because the picture points may be several photographs apart, the photogrammetric control points serve as a basis for tying the photographs together and bridging between the picture points.

79. Geodetic Control Base

To provide a base upon which to establish the intermediate network of photogrammetric control points, it is necessary to plot the geodetic control on the projection. The ground control plot may be laid out on either an opaque or a transparent base. The type of base used will depend upon the size of the project and the method of extending control, but it must have good dimensional qualities in either case. Polyethelene terephythatate (Mylar) sheeting having one matted surface makes a desirable transparent medium. The ground control sheet contains the grid lines, the projection ticks, and the ground control points. The projection ticks and all grid lines are normally inked in black. The ground control points are usually plotted by rectangular coordinates (par. 26) and all points are labeled with their correct designation. The horizontal control points are marked with red equilateral triangles approximately 7.6 mm high, with the pinpricked control point centered in the triangle (fig. 72). Sometimes crossed guide lines are used to indicate the location of the pin prick. The name of the control station is lettered in red ink beneath the triangle and may be in an identifying code referring it back to the trig lists. Since radial line extension of control is primarily used in planimetric mapping, only horizontal control is required.

80. Planning New Ground Control

Horizontal control is most advantageous when control lines are run at right angles to the lines of flight of the photographs. The interval between control lines depends upon ground conditions and the desired accuracy of

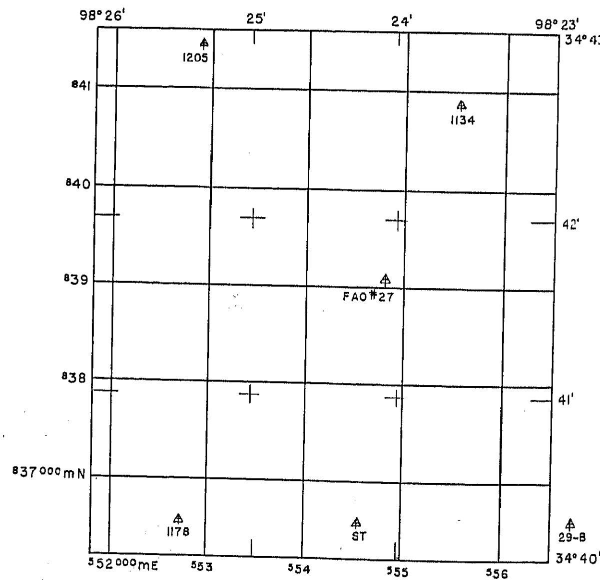


Figure 72. Geodetic control on base compilation.

the map. In military mapping, extension of control can be performed satisfactorily when control exists as far apart as 18 or 19 photographs. At least two horizontal control points must be located at both ends of each strip of photographs. These points must be spaced as far apart as possible within the initial or final pair of photographs to form a strong starting and finishing base. More than two points per strip give a stronger base. Where vertical control is needed to place contours upon a planimetric base, it should be planned with the horizontal control. TM 5–243 gives details of flight planning.

Section II. RADIAL LINE EXTENSION OF CONTROL

81. Purpose

The process of locating photogrammetric control points with respect to ground control is known as *extension of control*. Its purpose is to increase the density of control to provide a closer network of points about which photographic detail may be accurately plotted. It is also used as a base for laying controlled and semicontrolled mosaics. After the photogrammetric and picture points have been located in their true relative positions, they can be adjusted to the scale chosen for the compilation.

82. Methods

The extension of control may be performed by *stereoscopic methods*, by *graphical methods*, or by the *stereotemplet method*. Stereoscopic methods are based on a projected spatial model that facilitates automatic correction of relief displacement and may eliminate projected spatial tilt displacement. Graphical methods use standard photographic prints, and correct for relief displacement by the principle of radial line intersection. While the graphical methods assume tilt to be negligible, they are not as accurate as the stereoscopic methods. Mechanical methods of accomplishing the graphical extension and adjustment of control have been devised, such as the slotted templet method which is described in paragraph 86. Graphical methods for mapping from oblique photographs are discussed in appendix VI. The stereotemplet method differs from the other techniques of radial triangulation in that the stereotemplet is representative of the horizontal plot of a stereoscopic model rather than a single photograph. A stereotemplet is a composite slotted templet designed for use in conjunction with stereoscopic plotting instruments. The function of the stereotemplet is to maintain this scale relationship between any and all points plotted from a single model while allowing for the enlargement or reduction of the overall scale of the templet. Stereotemplets are adjusted to the desired common scale when the templets are assembled to satisfy horizontal control positions. Further information on stereotemplet triangulation is contained in TM 5–244.

83. Principles of Radial Line Mapping

a. Vertical Photographs. The radial line method is based on the principle of resection and intersection used by surveyors. In a photograph, relief and tilt both cause displacement of the photographic images from their true map positions. However, on a vertical photograph, relief displacement is assumed to be radial from the principal point or the center of the photograph. As a line is drawn from the principal point through the displaced image of an objective, the true position of the objective will lie somewhere on that line, although the exact point is not known (fig. 73). When two overlapping photographs are oriented so that the principal point on each coincides with its position on the other, then the intersection of the two radial lines through the two images of an objective will establish the true position of that objective with respect to the principal points (2, fig. 73). By orientation of the first pair of overlapping photographs to any desired scale, the relative positions of image points appearing on them can be established for the purpose of establishing the relative positions of image points on succeeding photographs. For example, figure 74 shows a set of photographs oriented to each other by radial line triangulation. Rays D_1 and C_1 radiate from the principal point "1" of the first photograph and rays D_2 and C_2 from points "2" to the principal point of the second photograph. Now if the second and third photographs are overlapped so that the principal point on each coincides with its position on the other, then rays D_3 and C_3

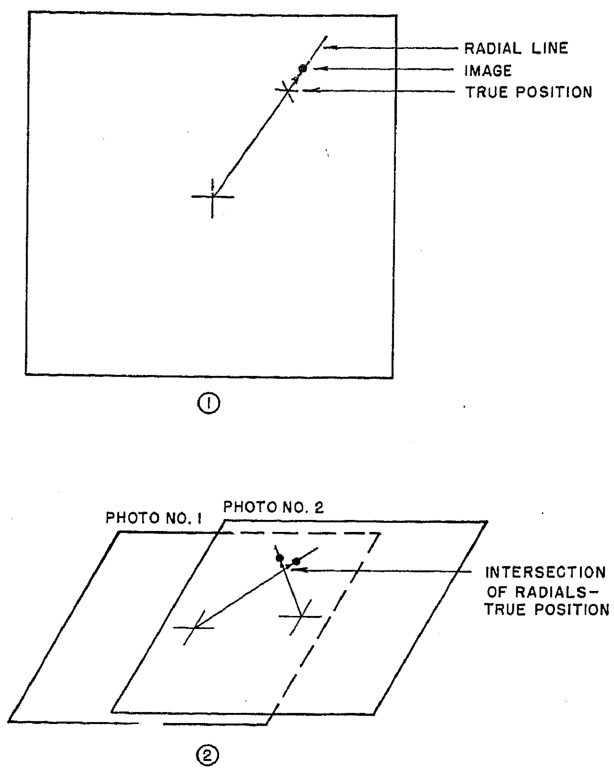


Figure 73. Location of image point through intersection of radials on a pair of photographs.

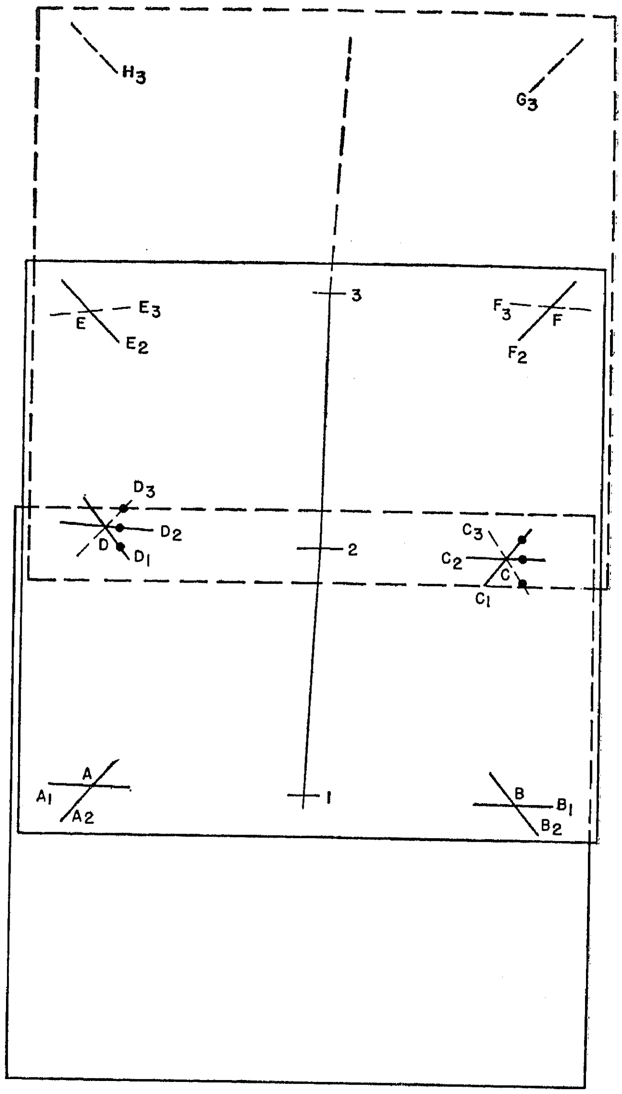


Figure 74. Establishment of positions by radial-line triangulation.

radiating from point "3" should intersect the other two sets of rays in common points. The points E and F are established, and are used in the same manner to continue the orientation of subsequent photographs until additional ground control is reached. This process of control extension is refered to as radial line triangulation.

b. Tilted Photographs. The radial line system is feasible in truly vertical photographs regardless of the amount of relief. However, in tilted photographs lines drawn through image points contain their true positions only when drawn radially from the isocenter and when there is no ground relief. If the tilt is under 3° and the ground relief does not exceed 10 percent of the flight altitude, the principal point may be used as the radial center and the radial line system can be used without difficulty. If any photograph contains defects caused by the photographic equipment, three-way radial intersections may contain small triangles of error.

84. Preparation of Radial Line Strip

a. Preparation of Photographs.

(1) The first step in preparing the photographs is to locate the principal point on each print. This point is located at the intersection of fine lines through pairs of opposite collimating or fiducial marks, and should be marked with an interrupted dash, not over 5 mm long (fig. 75). If there is any doubt as to the accuracy of transferring the principal point to the adjacent photographs, a substitute center may be selected as close to the principal point

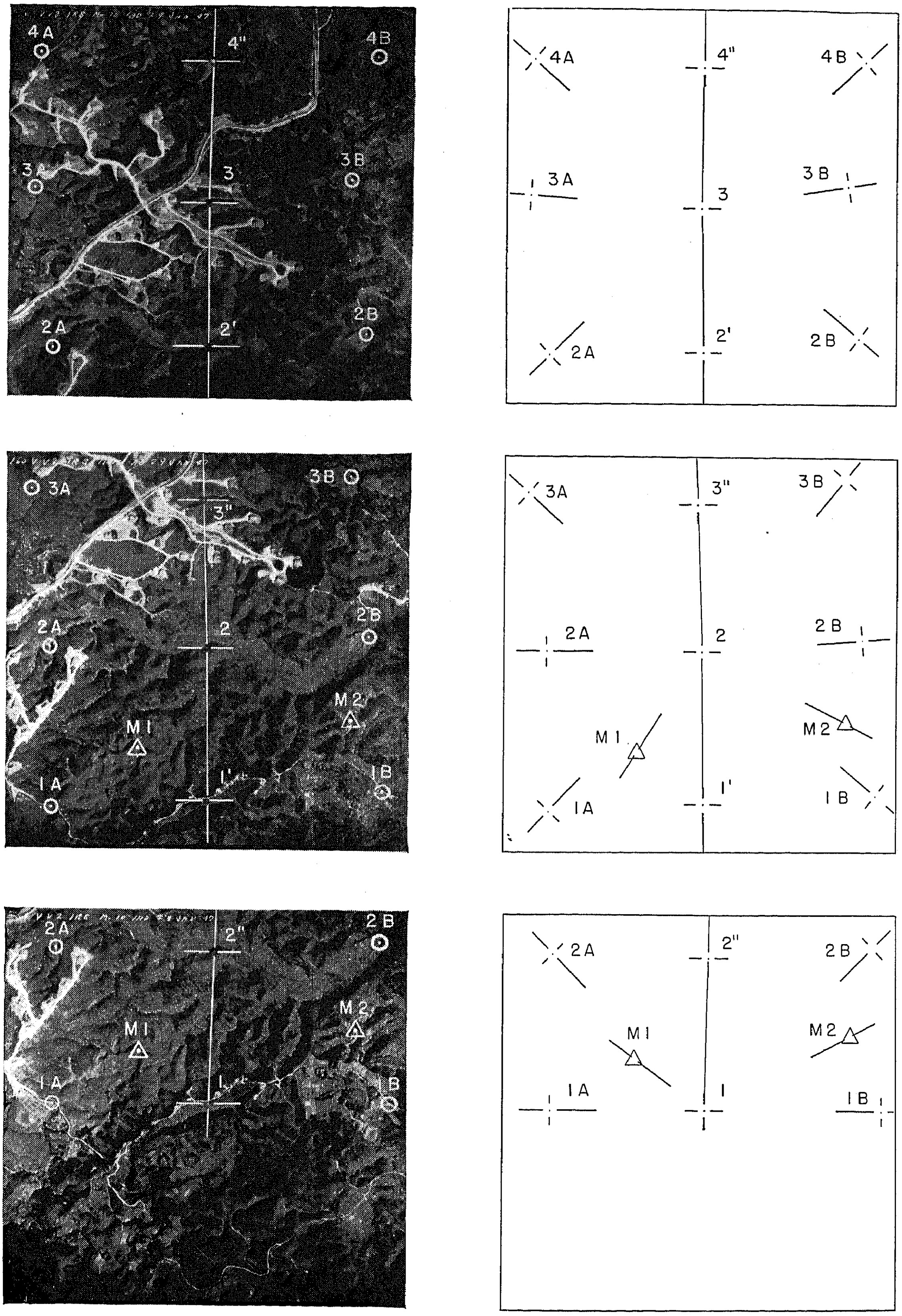


Figure 75. Ideal arrangement of control points on the photographs and appearance of corresponding templets.

as possible. Substitute centers must fall not more than 5 mm away at right angles to the flight line nor more than 10.0 mm away along the flight line. *All radial lines should be drawn from the true principal point.*

(2) Under a stereoscope this point is transferred to the succeeding and the preceding photographs so that each photograph will show three consecutive principal points (end photographs will show only two). The lines joining these points will then make up the approximate flight line. The principal point will rarely be located on a readily identified pinpoint of detail. Consequently, extreme care must be used when transferring points so that the transferred point will be in exactly the same location. (Note that because of drift the transferred principal point need not lie on one of the fiducial lines.)

(3) Except when the principal point is located precisely on a recognizable pinpoint of detail, the stereoscope models are drawn orthographically. The two photographs are laid side by side in line for stereoscopic viewing. The stereoscope is placed in position so that the principal point marked on the first photograph is in the field of view; this mark will then appear to be on the second photograph. If the photographs are properly alined, the point where the mark appears on the second photograph is the location of the transferred principal point of the first photograph. This point on the second photograph is pricked lightly with a pin or needle and marked as described in (4) below.

(4) Principal points are transferred and marked in ink by *black circles* 5.0 mm in diameter and numbered appropriately. Inking is usually done with the drop compass. In addition to the principal point, at least two additional points called *pass points* are selected.

(5) Additional control for accurate orientation of the photographs and plotting of detail is provided by pass points (sometimes called *wing points*). Pass points are clearly defined points of detail in a small overlap area common to three consecutive photographs. They must be positively identifiable on all photographs on which they appear. Pass points are selected approximately 76 mm away from the flight line and approximately in the center overlap area of the photograph. One point is first selected in about the proper location on the middle photograph of three overlapping photographs. The other two photographs are examined to insure that this point is identifiable on them as well. If more than one flight is used, the three adjacent photographs of the next flight are also examined. After a point has been ferred and marked. At least three photographs of each flight, it is transferred and marked. At least three pass points should be picked on each side of the photograph in the overlap area between the flights (fig. 75). The technician should, if possible, select pass points whose elevations are as near as possible to the elevation of the principal point. This will tend to reduce the tilt error to a minimum. Points located at lower elevations (in valleys) are preferable to those located on hilltops or peaks.

(6) Pass points are transferred in the same way as principal points. Take special care in transferring all points, because an error introduced in this step will delay the compilation later on and may carry through to the finished map. Each pass point is pricked lightly with a pin and marked in ink by a red circle 5.0 mm in diameter.

(7) A pass point will normally fall on three photographs of each flight, and if selected in the overlapping area of an adjacent flight it will fall on six photographs. Because of crab, drift, or offset photography, however, it will not always be possible to select a point falling on six photographs. This requires selection of an *auxiliary pass point* on the photograph on which the

pass point did not fall. This auxiliary pass point should fall on at least five photographs; it will not fall on the diagonally opposite photograph of the adjacent flight because the photographs are offset and there is no area common to all six (fig. 76). Each auxiliary pass point is marked in ink with a *double red circle* whose inside diameter is 5.0 mm.

(8) Picture points are also identified on the strips of photography. Each picture point is transferred from the photographs on which it was identified in the field to all photographs on which it appears, with the aid of a stereoscope. Each point is located on the photograph and pricked lightly with a pin held vertically to avoid offsetting the mark. The point is marked with a red equilateral triangle 7.5 mm high. The triangle should be approximately centered about the point, with the name or number of the control point lettered in red ink.

b. Radial Line Plot. The radial line plot is prepared on a single sheet of transparent material for each flight of photographs used. The geometry of this method results in the plotted strip being at the average scale of the first two photographs. This scale is rarely a round number, and if the strip is part of a compilation of a larger area, the control on this strip is later adjusted to the scale of the compilation sheet.

(1) After all control points have been selected, marked and checked, the photographs are laid out in proper sequence along the flight line. All pass points and control points are marked with a line or *ray* about 25 mm long drawn *radially from the principal point.*

(2) The first photograph is taped in place beneath the transparent radial line strip and the principal point and the transferred principal points marked on the strip with small ticks. The flight line is drawn connecting these points and extending about 12.7 mm beyond each one. Next, a ray about 25 mm long is drawn radially from the principal point through each geodetic and photogrammetric control point marked on the photograph (fig. 77). All lines must be drawn with a sharp 7H pencil, because the accuracy of the point depends in part upon the accuracy of the line width.

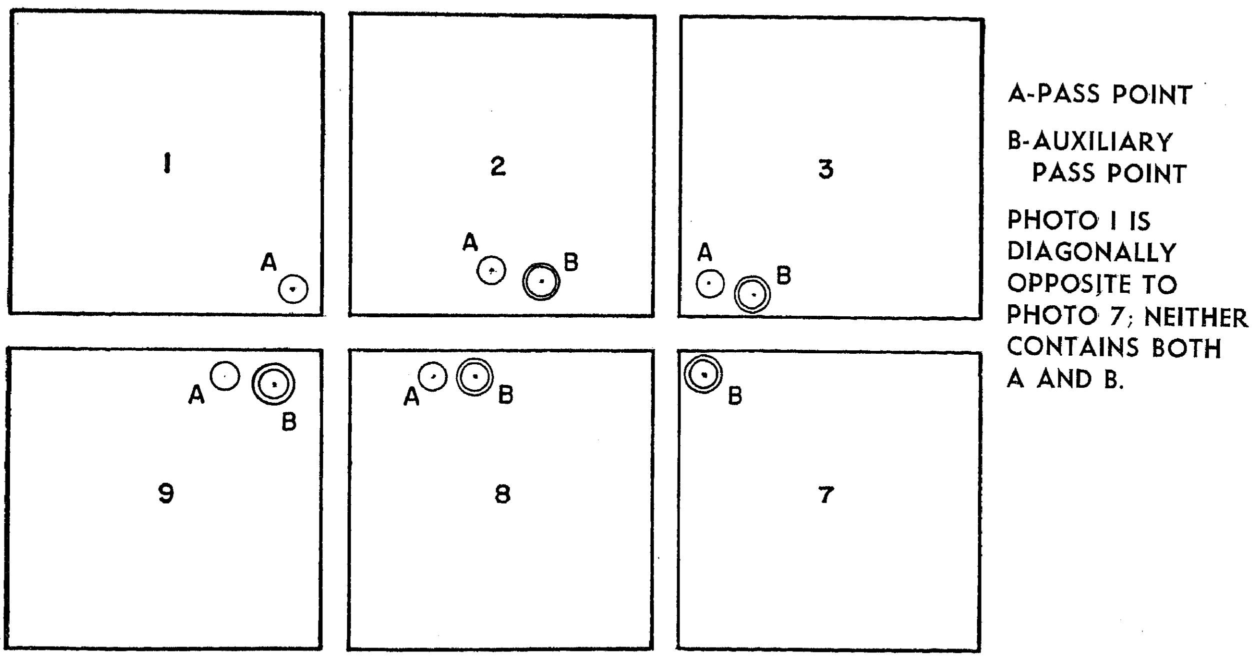
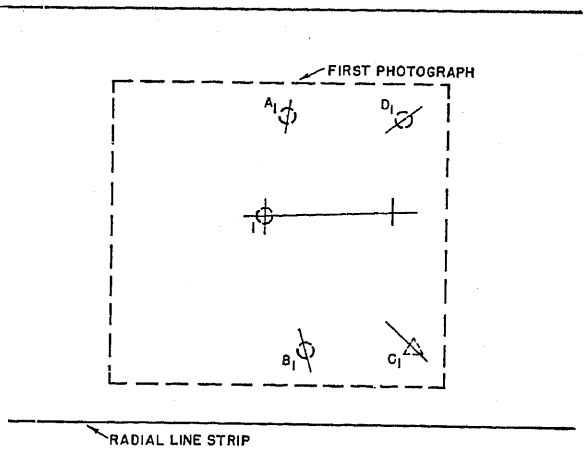


Figure 76. Selection of auxiliary pass point.



ure 77. Transferring rays from the first photograph to the radial line strip.

(3) The first photograph is removed and the second slipped beneath the strip. It is oriented so that the transferred principal point from the first photograph lies directly beneath that point on the strip, and its own principal point lies along the flight line of the strip. The failure of the principal point of the second photograph to fall directly beneath the point plotted on the strip indicates a difference in scale between the two photographs. This is adjusted by making prick marks on the strip halfway between the plotted center and the actual center of the second photograph (fig. 78). This adjustment, a compromise between the scale of the first two photographs, is the step that determines the scale of the entire strip. The second photograph is then moved along the flight line until its center lies directly beneath the adjusted center, and the transferred principal point of the first photograph lies along the plotted flight line. The second photograph is taped firmly in place.

(4) The new adjusted center of the second photograph is pricked and marked with a tick. The flight line is extended through the transferred principal point of the next photograph along the line and is not marked. Rays are drawn through all control points marked on the photograph radial from the principal point of the second photograph. The intersections of these rays now indicate the relative positions of the respective control points (fig. 79).

(5) The second photograph is removed and the third photograph slipped under the strip so that its own principal point and the transferred principal point of the second photograph both lie along the plotted line. The photograph is then moved along the flight line until the rays drawn on the photograph pass through the intersections of the same points on the strip. The principal points must remain alined with the flight line. There is only one

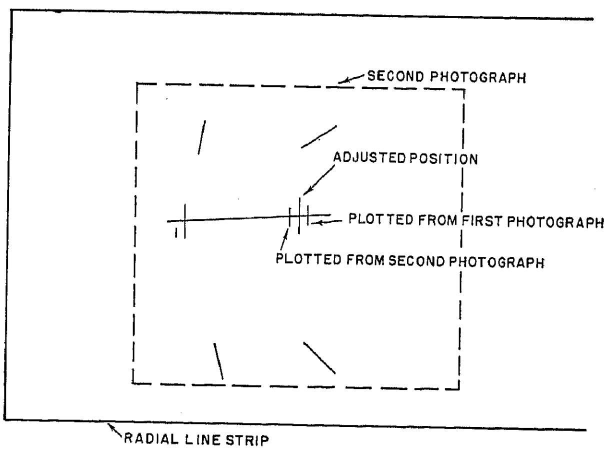


Figure 78. Adjusting the radial line strip to the average scale of the first 2 photographs.

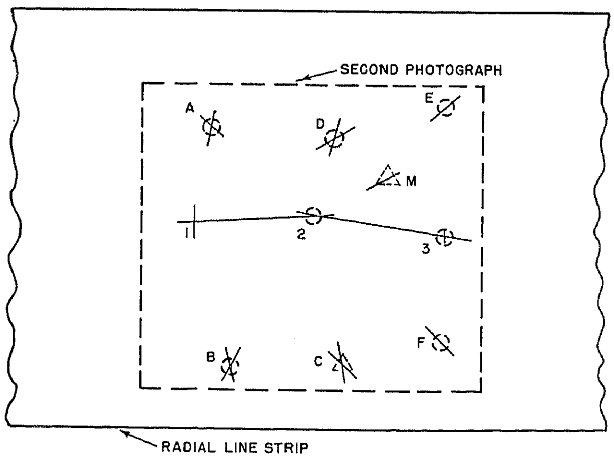


Figure 79. Transferring rays from the second photograph to the radial line strip.

position where radials and principal points will aline properly. This is the position on the photograph which has been oriented by resection from predetermined points and its control extended at the average scale of the first two photographs (fig. 74). The principal point of this photograph is pricked and marked on the strip and the flight line extended through the next transferred principal point. Rays are drawn on the strip, as before, through all control points marked on the photograph.

(6) The third photograph is removed and the fourth is oriented in the same way as the third. By a continuation of the flight lines, location of control points by 2-ray intersection, and orientation of the photographs by resection, the control is extended throughout the length of the strip. After all points have been located they are pricked lightly with a pin and labeled with a pencil. The control for the radial line strip is now complete (fig. 80).

c. Triangle of Error. Occasionally it will be impossible to obtain perfect 3-ray intersections on opposite pass points. This may indicate errors of draftsmanship or careless marking of points on the photograph. If this condition persists after points have been thoroughly checked, it is probably due to tilt or to faulty photographic equipment, and may be adjusted. To do this, shift the photograph along the flight line until the ray on one side passes as far *above* the intersected position of its point as the ray on the other side passes *below* the intersected position of its point. The rays are traced in this position, resulting in 2 small, balanced triangles where there should be perfect intersections. These are called *triangles error* (fig. 81) and their centers may be sidered the true positions of the correspc pass points. Careless marking of points on photographs, inaccurate plotting, and failure maintain the exact coincidence of flight li are more common sources of error than tilt or faulty equipment, so the photographs must always be carefully checked before triangles of error are accepted. When triple rays through picture points do not intersect in a point, the triangles of error between pass points are to be balanced rather than those occurring at the picture points, because the pass points are more nearly equidistant from the principal points of the photographs.

85. Adjustment of Radial Line Strip to Projection

Radial line strips plotted by hand are usually plotted to the average scale of the first two photographs, while the projection is plotted to the average scale of all the photographs in the project. The average scale is taken to the nearest 1/500. For example, projections may be plotted to a scale of 1/12,000, 1/12,500, 1/13,000, and so on. Consequently, the radial line strip is seldom the same as the projection, and all photographic control transferred from the strip

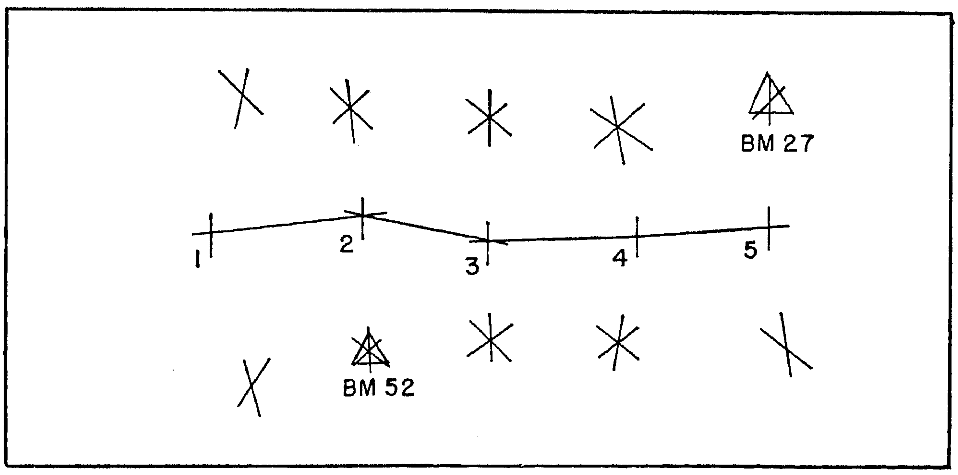


Figure 80. Radial line strip completed.

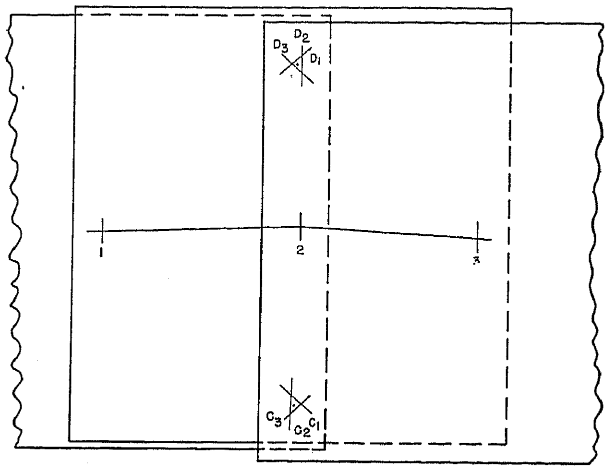


Figure 81. Triangle of error.

to the projection must be adjusted for this change of scale. Several methods of making this adjustment have been devised, all based on the ground control points which have been located definitely on both the projection and the strip. One method of adjustment uses a network of similar geometric figures, usually equilateral triangles plotted between the ground control points on both the strip and the projection. The photogrammetric control points are transferred to the projection by shifting the two networks to different positions of coincidence, and the detail is then plotted on the projection directly from the photographs. This is called the *similar figure method,* and is described in detail in *b, c,* and *d* below. An alternate mechanical method for adjustment of control is described in paragraph 86.

a. Construction of Triangles.

(1) Straight lines are drawn connecting the ground control stations on the radial line strip (fig. 82). Each line between 2 stations is bisected with a compass. Each segment of each line—such as AB in figure 82—becomes the base of an equilateral triangle. With the length of this base (AB or BC) as a radius, arcs are swung by compass from A, B, and C on both sides of the line. The equilateral triangles are constructed by joining the points where the arcs intersect. This procedure is continued until the entire strip between ground control stations is covered. If photogrammetric control points lie beyond the span of the ground control points, the equilateral triangles may be extrapolated by extending them at the same size beyond the last ground control point.

(2) Equilateral triangles are constructed between ground control points on the projection by the same method. It will be noted that the two patterns are identical in shape but not in size. This difference in size is due to differences in scale, and the identity of shape is the factor which permits adjustment.

(3) All construction should be thoroughly checked for accuracy before proceeding to the next step.

b. Transfer of Photogrammetric Control Points to Projection Sheet. The photogrammetric control points—principal points and pass points—are transferred from the radial line strip to the projection as follows (fig. 83):

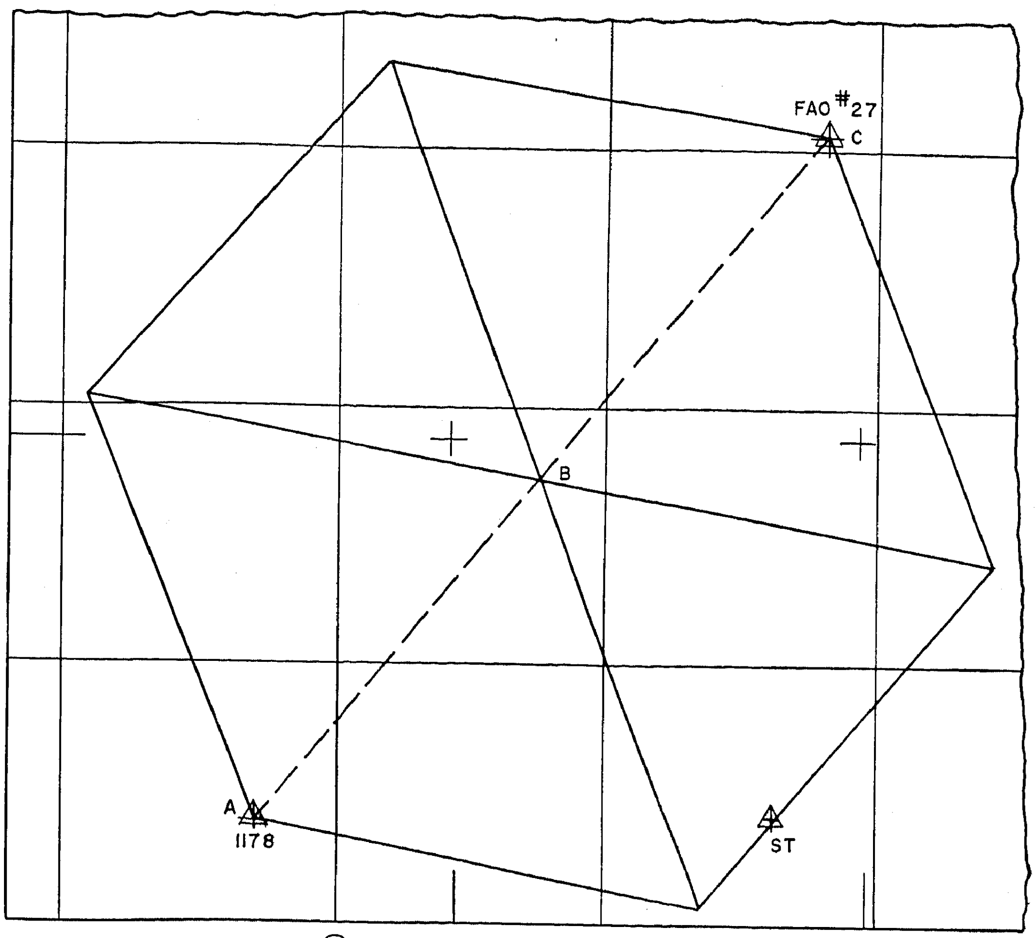
(1) Secure the radial line strip to the drawing board or table.

(2) Orient the projection sheet over the radial line strip so that an angle and two sides of a triangle, such as triangle ABC on the projection point at point A.

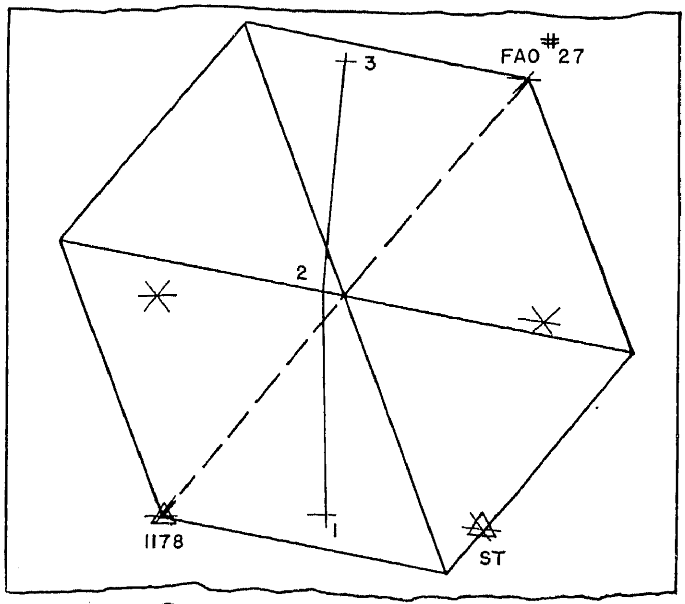
(3) Secure the projection to the table temporarily and draw lines approximately 25 mm long from the vertex of the coincident angle (A) through all photogrammetric control points within the triangle.

(4) Reorient the projection so that another angle and two sides of the same triangle, point B, are coincident. Again draw from the vertex of the coincident angle through all control points within the triangle. Each intersection with two lines locates the photogrammetric control point at the scale of the projection.

(5) As a check for accuracy, reorient the projection to the remaining angle of the same triangle point C; and draw lines as before, giving a 3-way intersection for each photogrammetric control point. This will show up errors in the construction of the triangles, improper orientation of the projection over the radial line strip, or inaccurate



(1) CONTROL PLOT



(2) RADIAL LINE STRIP

Figure 82. Radial line strip and projections with equilateral triangles.

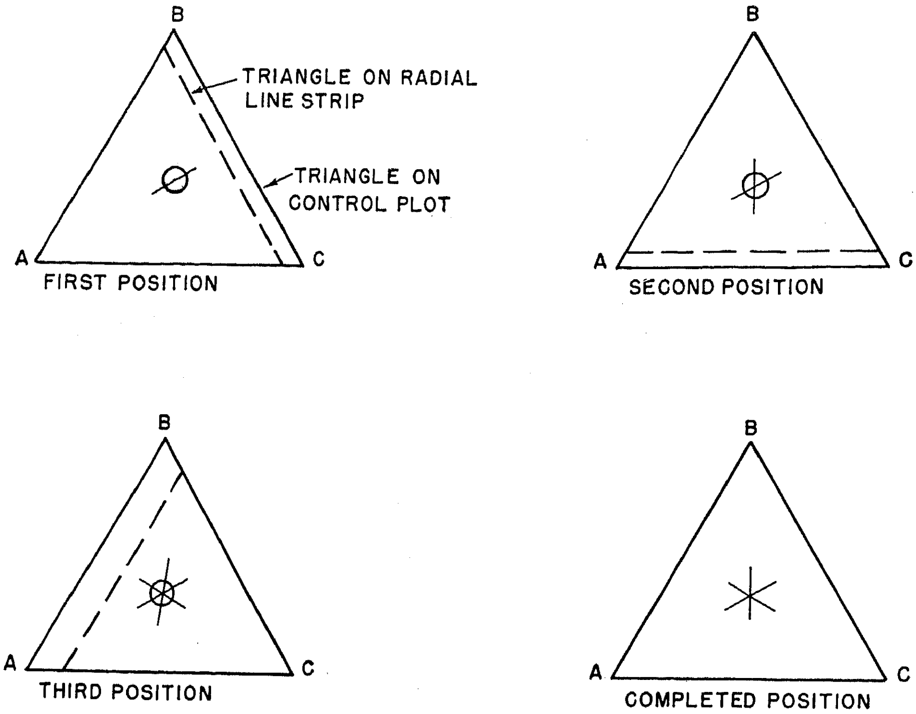


Figure 83. Transfer of photogrammetric control points by similar triangles.

drafting of the lines within the triangles. In case of an error, the steps should be rechecked individually, and the process repeated until the error is eliminated.

(6) Repeat (1) through (5) above for each of the equilateral triangles constructed.

c. Additional Radial Line Strips. The above procedure is used for each radial line strip (flight). Pass points common to two flights may not coincide on the projection because of minor errors in the selection and marking of the photogrammetric control points, in the orientation of the photographs to the radial line strip, or in any of the drafting steps throughout. If two pass points fail to coincide, the point should be assumed at a mean between the two points plotted. If the error between the two points is greater than 2.5 mm, however, all work should be checked to determine its source.

d. Marking of Points. All principal points are marked on the projection sheet with a black circle 5.0 mm in diameter, and labeled with the photograph number. All pass points are marked with a red circle, but are not numbered. Colors and sizes of these circles may vary from one topographic unit to another. The photogrammetric control points are now in their proper positions at the scale of the projection, where they provide control for the final step—compilation of planimetric detail on the projection sheet.

86. Slotted Templet Method of Control Extension

a. Methods. The slotted templet method was developed on the same theory as the radial line method of control extension. Both are graphical methods in that they locate points in their true position by a network of triangles. The difference is that most of the hand drafting in the radial line method is replaced in the slotted templet method by a mechanical aid (templet). In order to distinguish between these two methods, the use of templets or other aids is usually referred to as a mechanical method of extending control.

b. Applications. In the slotted templet method, a templet is substituted for each photograph (figs. 75 and 84). All points are transferred from the photographs to the templets, and a slot is cut through each point, radial from the principal points. These templets are then

assembled by placing studs in the slots and placing the centers over their transferred positions on the adjacent templets; the use of a slot rather than a single hole allows the mass of templets to be expanded or compressed to fit the fixed control points of the projection. This method locates the pass points between flights in their proper relative position by 6-ray intersections, and the principal points by resection from these pass points. When the control stations on the templet are placed over the control stations plotted on the projection, the pass points and principal points are in their proper location at the scale of the projection.

c. Advantages. Control can be extended successfully by this method, eliminating much of the human error which shows up in the drafting of the radial line method. The slotted templet method is better suited to large areas, since the procedure is readily subdivided into steps that can be done at the same time by different groups or individuals.

d. Preparation of Templets.

(1) The templets may be made of any of several different materials, such as plastic (heavy), cardboard, tin, and bristol board. The templet must be rigid to keep it from buckling when assembling and scaling the mass of templets. Cut the templet material to have a 25 mm margin around the photographs to allow for points that fall near the edges of the photographs.

(2) Each templet is representative of a single photograph and is marked directly from the photograph. Attach the photograph over the templet by small pieces of masking tape. This will hold it firmly in place while the points are being transferred. With the photograph and templet fastened together, transfer all marked points to the templet by pushing a fine needle through the points on the photograph. Place the photograph and templet on a flat surface, and keep the needle perpendicular while transferring the points. One end of the photograph can be freed and the transferred points marked for identification. Number the center point, transferred centers, and ground control stations to facilitate

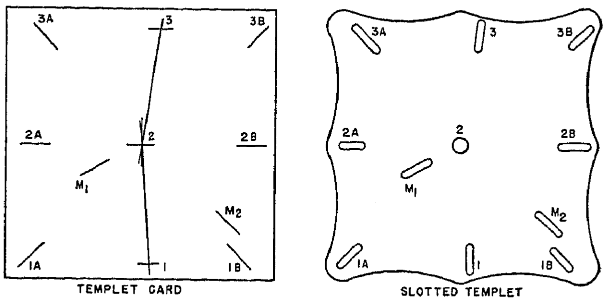


Figure 84. Marked and prepared slotted templets.

identification when laying the templets (figs. 75 and 84).

(3) The templets marked as in (2) above are now ready for slotting. Punch through the center point of the templet by orienting the point under the center point of cutter and depressing the handle slowly but firmly (fig. 85).

(4) Next, slot the secondary points and ground control points. Orient the templet in the mechanical slotter by placing the punched center hole on the centering stud of the slotter. This centering stud moves back and forth in a long groove which is directly in line with the slotting die. This movement allows the die to reach all points on the templet except those within 38 mm of the center. The templet itself can be rotated about this stud to bring the pass or control point directly under the punch. Cut the slot by depressing the cutter handle so that centering pin is directly over the point, then depress the handle fully.

(5) The mechanical slotter will cut slots for all points outside a radius of 25 to

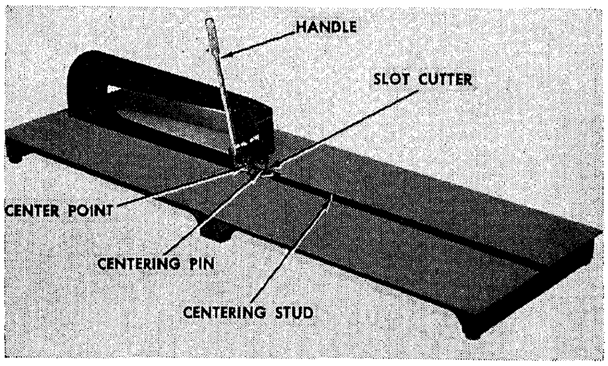


Figure 85. Templet slot cutter.

38 mm from the center point. Any points falling within this radius are slotted by a second method. With the center stud in place in the templet, mount a radial line rule on the center stud and draw a line from the center to the point to be slotted, extending it 50 or 75 mm beyond this point. Punch an auxiliary hole for the centering stud along this radial line at such a distance from the point as to bring it within range of the slotter. With this hole punched, cut the slot in the same way as for all other points; take care not to cut any part of the original center hole.

(6) When using the slotter, the handle should not be depressed too rapidly, but should be pressed down firmly and evenly. This enables the punch to "set" before punching through and eliminates any chance of its catching on the side of the die.

(7) With the slotting completed, trim the templets to eliminate excess templet material which may interfere with slots of adjacent templet points.

e. Slotted Templet Laydown.

(1) Fasten the ground control sheet to a large wooden board. With the control plotted on the projection, place control pins running through a templet stud into exact coincidence with the primary control points plotted on the base. By using the stud as a guide, these pins may be firmly driven into the base material in their proper coordinate positions and imbedded deeply enough so that there will be no possibility of the stud changing its position when the adjustment of the templet takes place.

(2) The assembly can be started from any single picture and with any flight, although it is preferable to start with the flight strip near the middle having the most ground control. This is desirable because the accumulated error will be less when starting from a central flight than when starting from an edge flight. Beginning at a control point, a templet is placed with the fixed stud on the compilation base inserted through the slot for that control point point on the templet. Slide additional floating studs under the templet through the principal hole and the remaining slots. Place the next templet overlapping the first so that the slots to all control points fit all the corresponding studs placed on the first templet. Superimpose additional templets in the same way, usually proceeding first along a line of control points and then outward from the templets already fitted.

(3) As the templet assemblage reaches other control points it may be that the control points may fall correctly upon the points already plotted. In that case, pin the control stud in its position and add subsequent templets. Quite often when more than a few templets have been employed in bridging from the last control points, the fit will not be correct. Trial will show that there is a slight give or play among the templets which can be worked gradually in the direction necessary to bring the templets to agree with the plotted point. Absolutely no force or pressure should be used beyond a gentle agitation of the templets and a taking up of new play, which will be very small but enough to permit the templets to be fitted to all control points.

(4) Occasionally a single templet fails to fit over those already placed so as to fall smoothly into position. Investigation will show that one of the photogrammetric control points had been incorrectly transferred from adjoining photographs or carelessly plotted on the templet, or that an error has been made in cutting the slot. The mistake must be rectified and a new templet cut.

f. Marking Control Points. With the templets laid and control studs through all the points, a fairly rigid mass of templets should result (fig. 86). The points found by this method can now be transferred to the manuscript by pricking through the stud with a pin

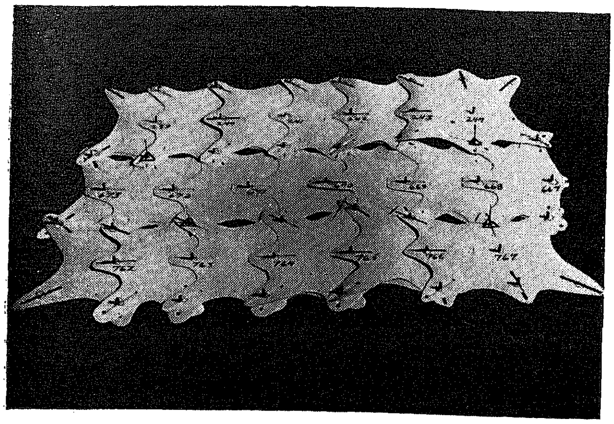


Figure 86. Slotted paper templet assembly.

having a close tolerance to the centered hole in the stud. Then lift the templets singly and circle the pricked points on the manuscript in black lead pencil; number the centers for easy identification. After the templets have been removed, circle the centers in 5.0 mm diameter blue circles, and the pass points in 5.0 mm diameter red circles.

87. Radial Arm Templets

Radial arm templets represent a modification of the slotted templet method. The radials are here represented by precut slots in thin metal arms of various lengths which are bolted together at the center of radiation. Some advantages of the radial arm templets are that the metal templets eliminate the tendency of studs to dig into the comparatively soft material of the cardboard templets and that the metal templets can be dismantled after use and reused, whereas the cardboard templet can be used only once. To prevent corrosion of the metal templets, special stainless steel templet sets have been developed.

a. Preparation of Photographs and Templets. Photographs are prepared in a way similar to that previously described for cardboard templets.

(1) Identify the principal point, control stations, transfer principal points and a minimum of six pass points on the photograph. Draw azimuth lines through all points radiating from the principal point.

(2) Mount the photograph on a suitable mounting board and insert a capped pin through a templet stud and through each control point, pass point, and photo center (fig. 87). Select metal arms of such length that when the last hole at one end is placed over the photo center bolt the middle of the slot at the other end will fall over the pass point stud. After all the arms have been assembled over the templet studs in their proper orientation, a washer and retaining nut (fig. 88) are placed over the bolt and the nut is tightened. Care must be taken when tightening the nut to hold the base of the bolt and washer on top of the arms with the

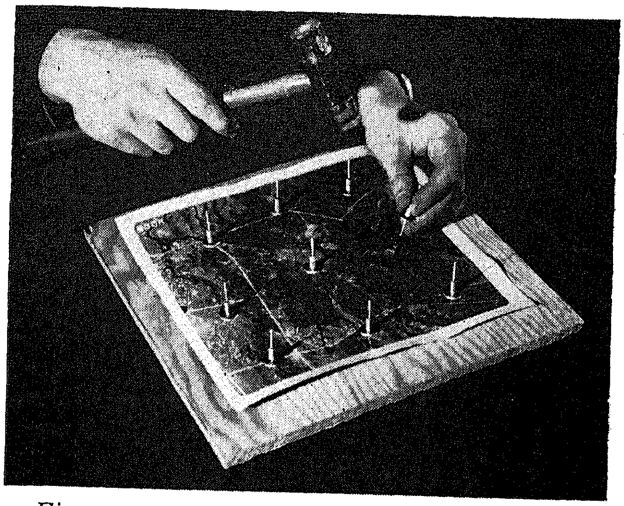


Figure 87. Placing pins through control points.

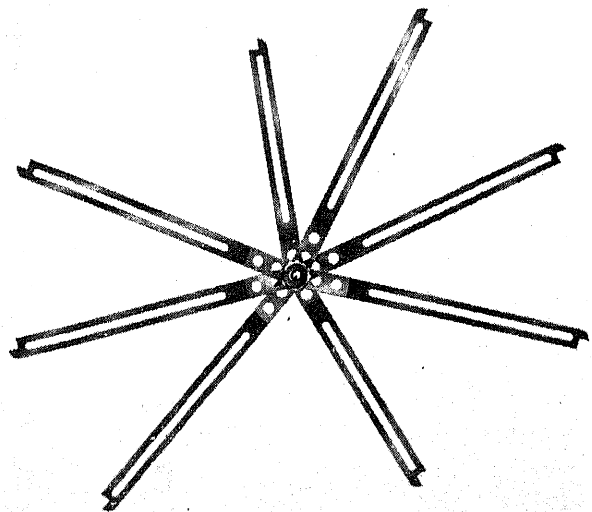


Figure 88. Radial arm templet.

double-hex wrench to maintain proper orientation of the radial arms. The templet is marked for identification and orientation with the photograph, and then lifted off the control pins ready for the templet assembly.

b. Assembly and Orientation of Templets. Assembly of the templets is the same as for the slotted templets of paragraph 86. Figure 89 shows a radial arm templet assembly.

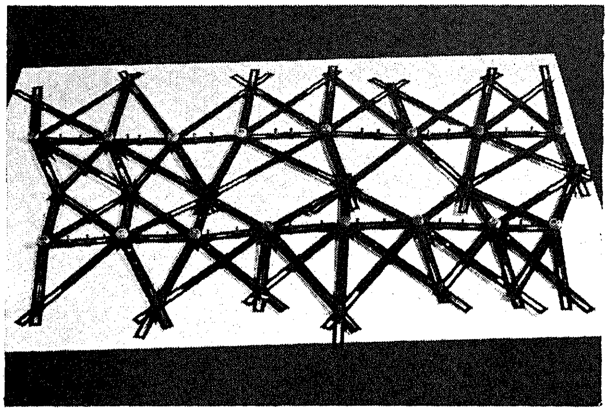


Figure 89. Radial arm templet assembly.

88. Multiplex Triangulation

The purpose of multiplex triangulation is similar to that of radial line triangulation—to establish the true positions of a series of image points between bands of ground control in order to create a system of control points which will insure the position accuracy of all topographic features plotted within them. In the multiplex system, horizontal and vertical bridging are done simultaneously, whereas, radial line triangulation is horizontal bridging alone. The extension of control with the multiplex involves the proper orienting, scaling, and horizontalizing of one or more models in which suitable control information is available; and the use of additional projected images to form a continuous strip of stereoscopic models. See TM 5–244 for details of multiplex triangulation.

Section III. CONTROL OF MOSAICS

89. Controlled Mosaics

Controlled mosaics are laid to ground control which has been augmentated by radial line or slotted templet positions. Prints are used which have been rectified as shown to be necessary by this control. The controlled mosaic is assembled on a rigid mount of vehisote, masonite, plywood, lightweight metal boards or similar material and is known as the mosaicking board. First, a projection at the final mosaic scale is constructed on this board and all available horizontal control which can be identified is plotted. The final mosaic scale can be at reproduction scale or 25 percent larger. The control information is then transferred to a transparent stable-base overlay upon which a radial line or slotted templet extension of this control is executed to locate the positions of nine points in each photograph.

90. Double Templet Method

a. Method. In order that all image points on the photographs will fit their plotted positions, it is necessary to rectify the photographs to correct for the effects of tip or tilt and to enlarge or reduce the photograph to the scale of the projection on the mosaicking board. A mechanical method for making this rectification and change of scale by using a photogrammetric rectifier has been devised. This method involves preparation of double templets of control. One templet (bottom templet) contains the control points to the same scale and in the same position as they occur on the radial line plot. The other templet (top templet) contains the same control points in the position and scale as they occur on the photographs. Both templets are then inserted in the photogrammetric rectifier and the projection of the top templet in the head of the rectifier made to coincide with the bottom templet on the easel. The bottom templet is replaced with positive photographic paper while the top templet is replaced with the negative film of the photograph. A rectified positive print is then made to the same scale as the bottom templet.

b. Preparing Bottom Templets.

(1) The radial line plot on a stable base film contains all the photo control points including the principal points, transferred principal points, pass points, and geodetic control points. A templet of bristol board or of stable

base film is placed under each principal point, and all the control within the area of the photograph represented by the principal point is pricked through and marked on the templet. All symbols should be carefully centered with respect to the pricked points they identify. The symbols used are the same as those on the radial line plot.

(2) Sometimes a roll of stable base film is used as the bottom templet. When this is done, the groups of control points are arranged in the sequential order of the principal points to aid in finding templets quickly (fig. 90).

c. Preparing Top Templets.

(1) In preparing top templets each photograph is taped to a drawing board and stable film base fastened down on top of the photograph. The same control points identified on the bottom templet are transferred from the photograph to the top templet and are similarly marked. Templets may be either individual sheet film templets covering one photograph each, or may be sequentially arranged on a roll of stable base film (fig. 91).

(2) Sometimes duplicate negatives can be used for the top templet. The control points can be pricked on the duplicate negative with a needle point positioning the film over the marked point on a light table. When time is critical, a red ink dot is used which can be removed later with a damp sponge. Use of duplicate film will speed up the work on a large mosaic job.

d. After the top and bottom templets have been prepared, they are ready for rectification.

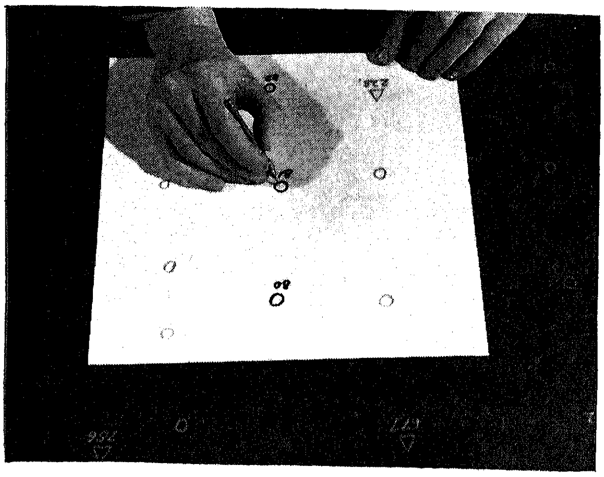


Figure 90. Preparing bottom templets.

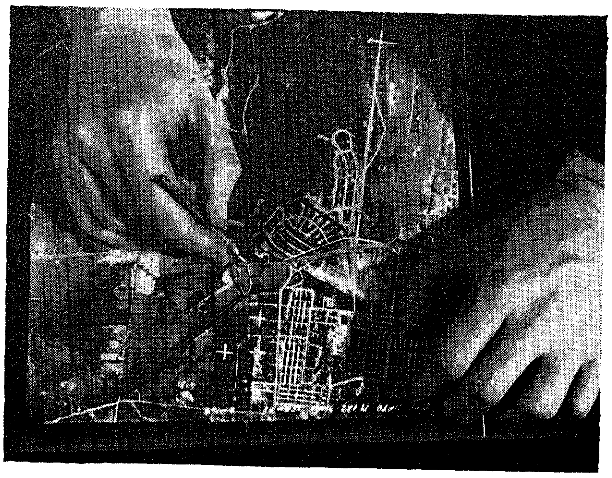


Figure 91. Preparing top templets.

Section IV. THE AUTOFOCUS RECTIFIER

91. Introduction

a. Optical rectification is the process of projecting the image of a tilted aerial photograph into a horizontal reference plane to eliminate the image displacements caused by tilt of the aerial camera at the time of exposure. The photographic print produced by such a projection will possess all the geometrical characteristics of a vertical photograph taken at the same position in space. This projection is accomplished by means of a rectifier. To project the image correctly, certain mathematical relationships must be maintained between the rectifier's negative plane, lens, and easel. Rectifiers for this purpose are of two main types: those in which the *optical axis of the rectifier lens* is the common reference or base direction of the instrument, and those in which the line between the principal point of the negative and the rectifier lens is the common reference. The autofocus rectifier is an example of the first type and the high-tilt rectifier is an example of the

second type. Rectification with the autofocus rectifier is accomplished either by matching points to a control templet, or by the method of computed data; with the high-tilt rectifier, rectification is accomplished by the method of computed data.

b. The point-matching method is based upon the matching of the images of four or more points on an aerial negative or a transparent overlay of the negative to the correct horizontal positions of the same points plotted upon a templet or map. The matching is carried out by tilting the easel, changing the magnification, and rotating and displacing the negative in its own plane until the projected images match the images on the easel templet or plot. Use of the control templet on the easel in conjunction with the aerial negative in the instrument is called the one-templet method of rectification, while use of the control templet on the easel in conjunction with a transparent overlay of the aerial negative in the instrument is called the two-templet method. Control points are sometimes difficult to identify in the projected image of the negative and since permanent marks should never be made on the original aerial negatives, the two-templet method is somewhat easier because all extraneous detail is eliminated on the transparent overlay.

c. The computed data method requires that the amount of tilt and its direction in the aerial photograph be known as well as the focal length of the aerial camera, the focal length of the rectifier lens, and the magnification ratio. The tilt data can be derived from an analysis of the contact print by any one of the standard procedures or from data incident to other instrumental use such as stereoplotting.

92. The Instrument

a. *Description*. The autofocus rectifier (fig. 92) is a precise, vertical photoenlarger which permits the correction of distortion in the negative caused by tip and tilt. The printer has an automatic focus, with provisions to tilt the easel and lens, and to swing and displace the negative in a horizontal plane. The negative remains in a horizontal plane at a fixed height, while the lens and easel may be moved along the axis of projection. The lens and easel are mounted in a swing pivoting at the negative plane so that they may be swung as a unit about an axis through the plane of the negative to provide tilt adjustment. As this swing is actuated, the easel tilts with respect to the axis of the lens. All of the motions, except the swing and displacement of the negative carriage in a horizontal plane, are motor-driven and are interconnected by mechanical linkages designed to maintain sharp focus automatically in the projection of all possible settings.

b. *Physical Characteristics*.

Height	70 inches (178 cm)
Width	55 inches (140 cm)
Depth	52 inches (133 cm)
Weight, uncrated	825 pounds (374 kg)
Weight, crated	1,850 pounds (819 kg)
Negative displacement X ±	90 mm
Y	120 mm
	100 mm is zero.
	46 mm back.
	Swing 360°
Illumination ..	4 foot-candles in projection at 1:1 magnification and zero tilt.
Easel size	36 by 33 inches.

c. *Optical Characteristics*.

Lens	Focal length 5½ inches. Aperture stops f/6.3, 8, 11, 16, 22, 32.
Distortion	0.4-mm maximum at zero tilt and IX and 2X magnification.
Resolution	22 lines/mm in center of field at f/8 and 2X magnification.

93. Capabilities

The autofocus rectifier can be installed in mobile mapping vans and can rectify 9- by 9-inch photography of either 6- or 12-inch focal lengths with tilts up to 20° throughout a magnification range of 0.7 to 3.3.

94. Operation

Motions of the rectifier (fig. 94) are—

a. *Magnification*. Magnification of the projected image is increased or decreased by a motor drive controlled by a hand button. The image stays in sharp focus at all times. The effect of magnification upon image points projected on the easel is shown in 1, figure 94. Point 0 is where the optical axis intersects the tilt axis of the easel. Magnification displacements are radial from this point.

b. *Easel Tilt*. The easel tilt of the instrument is also motor driven and is coupled to the negative tilt so that only one hand control is needed for tilt, thus fulfilling the condition of intersection of easel, lens, and negative planes in a common line to maintain sharp focus. An in-

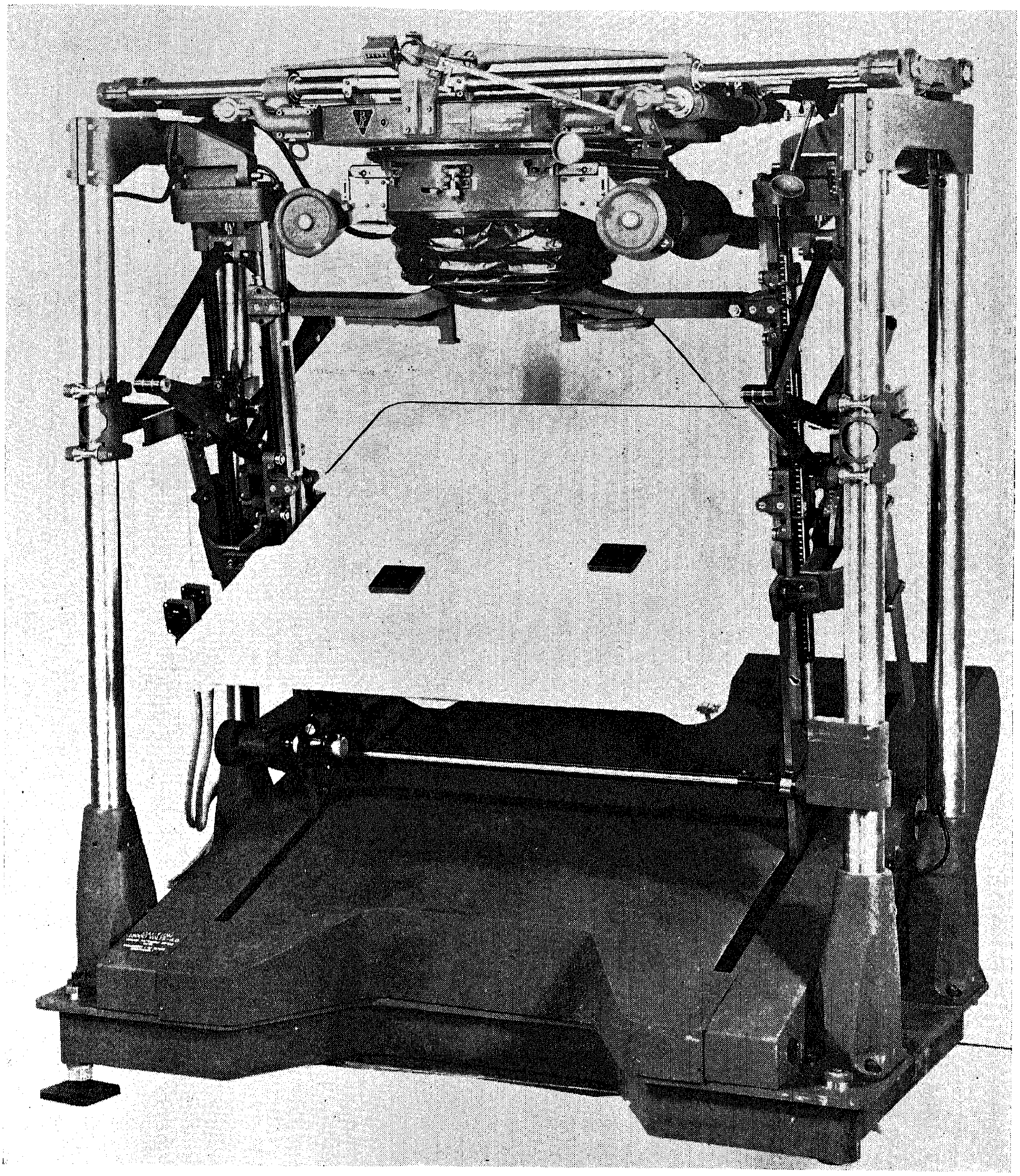


Figure 92. Autofocus rectifier.

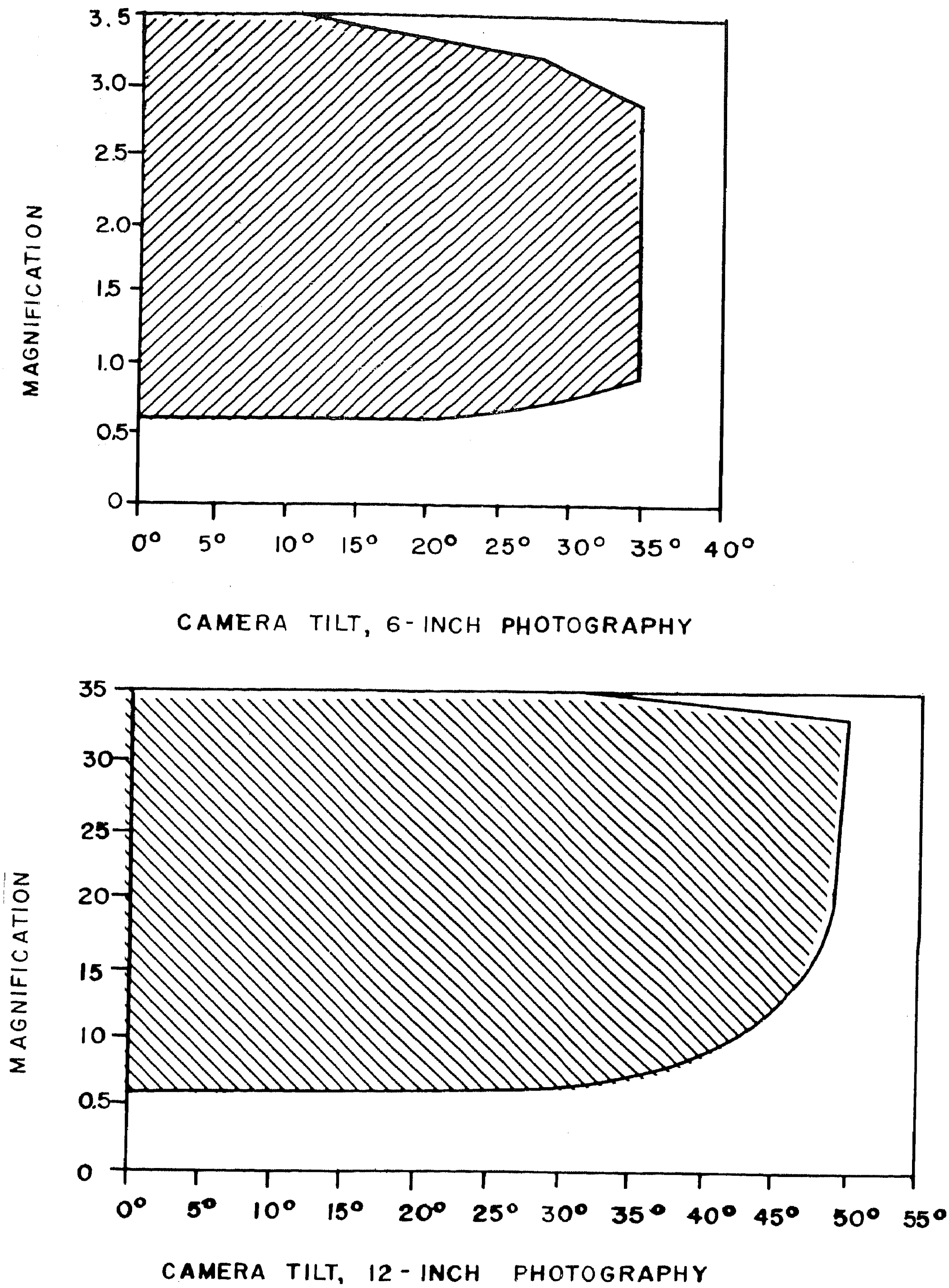


Figure 93. Magnification and tilt ranges.

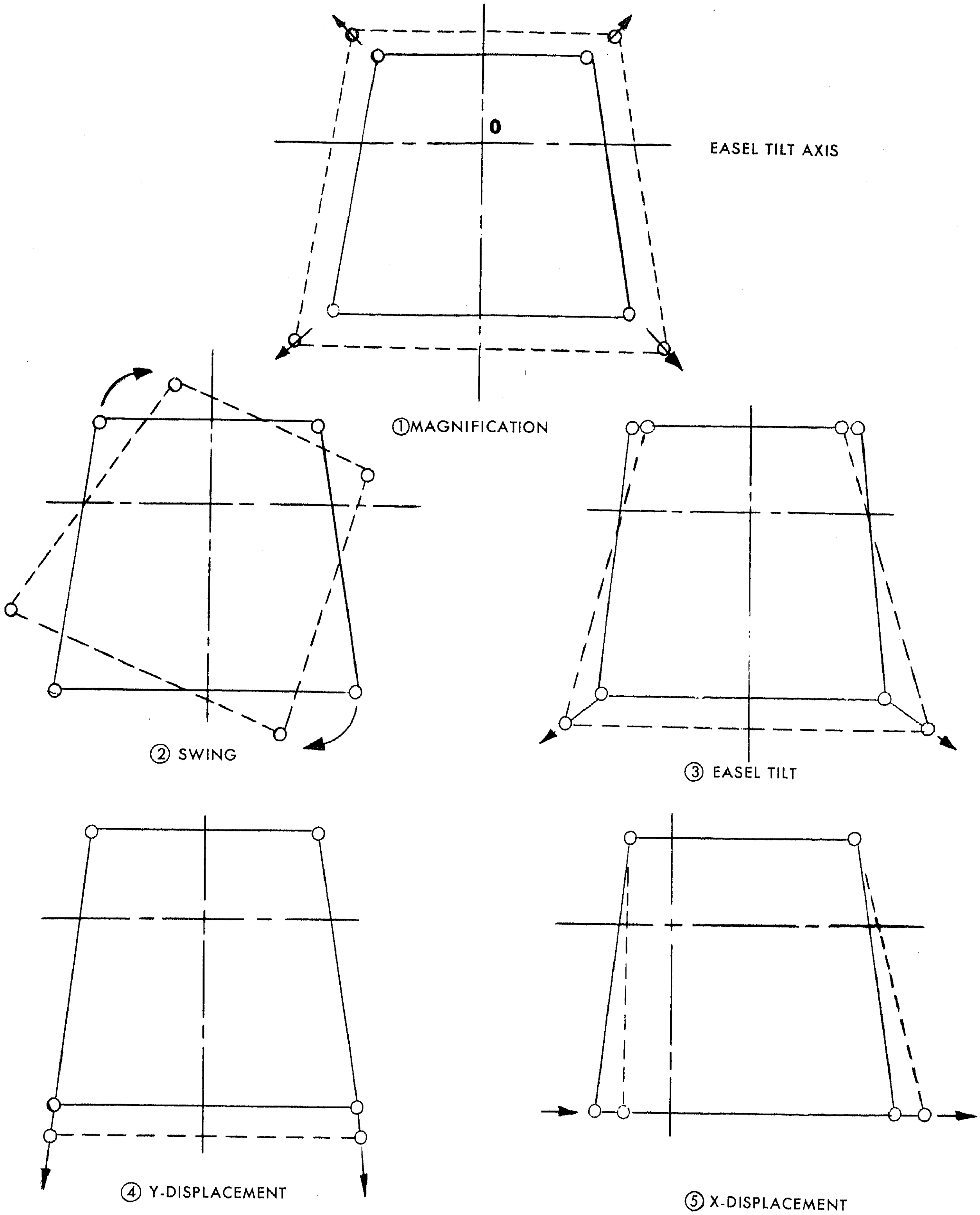


Figure 94. Rectifier instrument motion.

crease in easel tilt causes a lengthening of lines in front of the axis of tilt and a shortening of lines behind the axis as shown in 3, figure 94. The farther the images are located toward the front of the easel the more they will be displaced. Increasing the easel tilt increases the convergence of lines perpendicular to the axis of tilt.

c. Swing. The swing of the negative about its principal point is controlled manually. It may be swung clockwise or counterclockwise as far as desired. If some easel tilt is present, images which need to be displaced the most may be swung toward the front of the easel (2, fig. 94), with results as described under *b* above.

d. Y-Displacement. The Y-displacement is a displacement of the negative in its own plane perpendicular to the axis of tilt of the easel, and is hand operated. The Y-offset causes a movement of images toward or away from the front of the easel. With the easel tilted, points toward the front edge of the easel will be displaced more than points to the rear of the easel, but there will be no change in convergence of lines perpendicular to the easel tilt axis (4, fig. 94), as happens with easel tilt.

e. X-Displacement. The X-displacement is a displacement of the negative in its own plane parallel to the axis of tilt of the easel and is hand operated. It causes a shear deformation when the easel is tilted. Displacements are parallel to the axis of tilt of the easel and increase with the closeness of the images to the front edge of the easel, as shown in 5, figure 94.

95. Rectification Procedure for Point-Matching Method

a. Initial Step.

(1) In rectification by the point-matching method, it is much better to rectify by analyzing the type of displacements present between image and map points and deciding which motion or motions are necessary to effect coincidence, rather than by memorizing a fixed-step procedure which may not work for all situations.

(2) Rectification of a tilted aerial photograph should always begin with all settings on the autofocus rectifier at zero. If trouble is encountered during rectification and the situation becomes confused, it is better to reset all motions to zero and begin again.

(3) In the description of the actual operation of the autofocus rectifier which follows, the points on the control templet are plotted in correct horizontal position and will be referred to as map points, and the points in the aerial negative will be referred to as image points. Figure 95 shows a tilted photo with four points marked, an overlay of the negative, and an easel templet with the correct horizontal positions plotted thereon.

b. Bringing One Side into Coincidence. Bring one side of the image quadrilateral (1, fig. 96) into coincidence with the corresponding side of the map quadrilateral by shifting the map templet and varying the magnification, so that the two remaining image points remain inside the map quadrilateral (2 and 3, fig. 96). It may be necessary to try successive sides before this is achieved. The side brought into coincidence will be referred to as "A" and the other sides

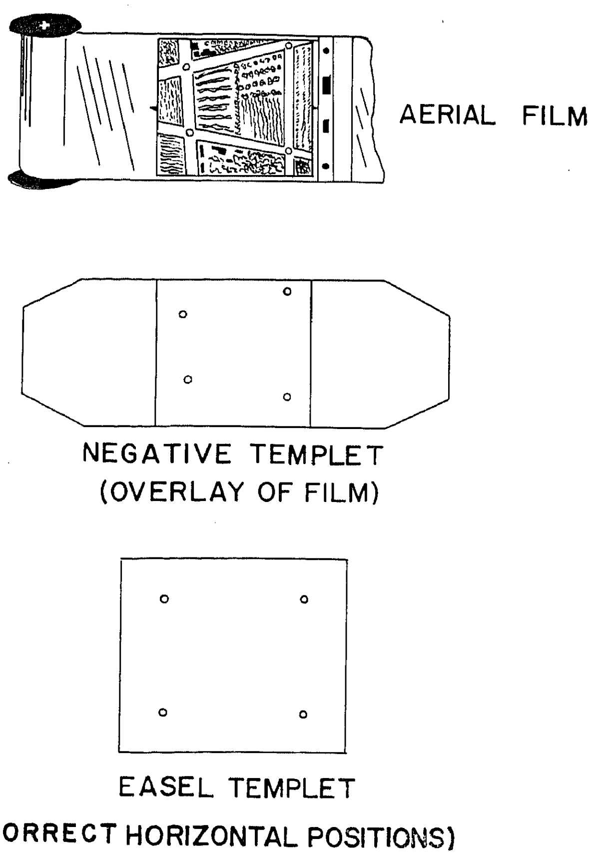


Figure 95. Rectification templets.

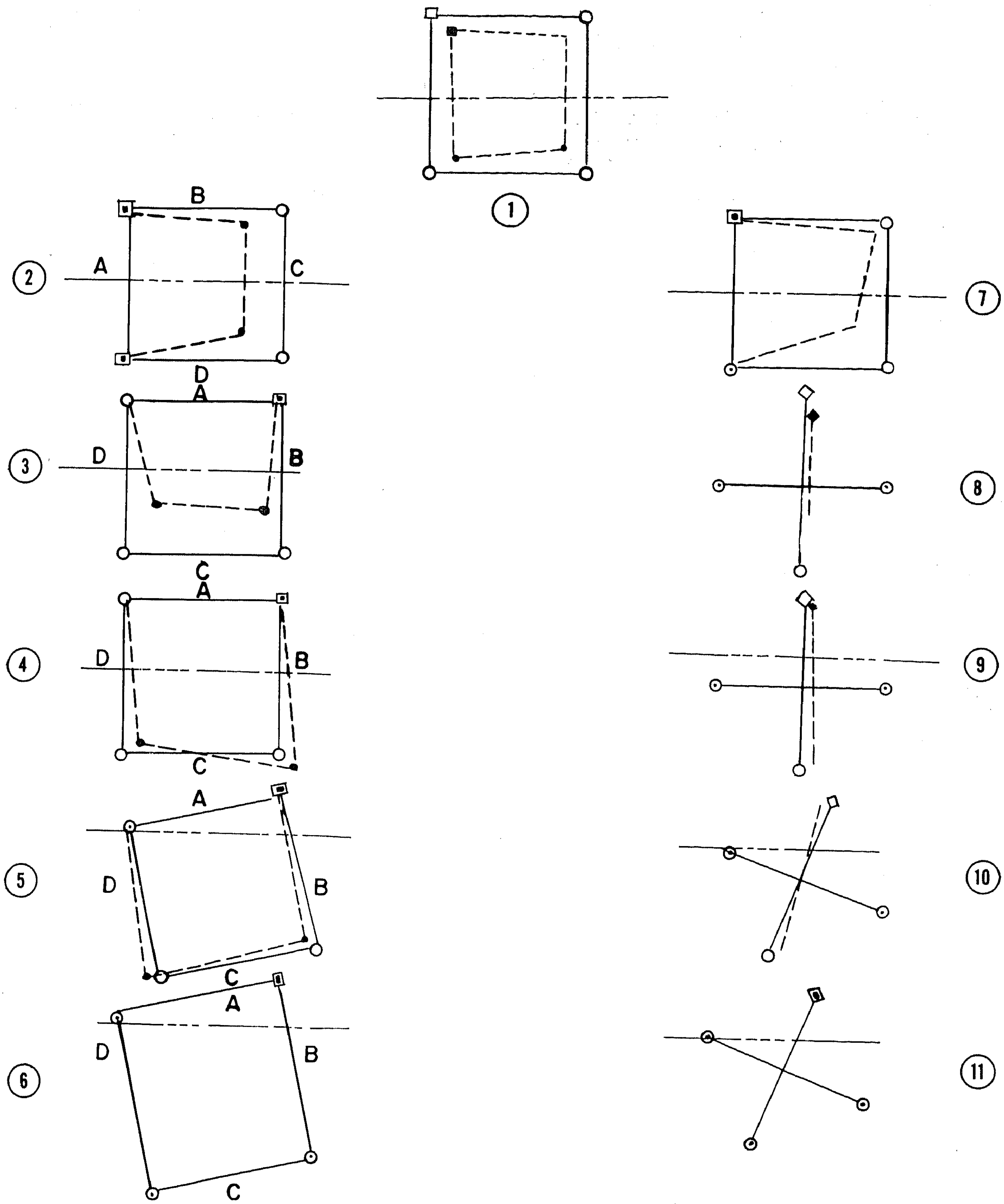


Figure 96. Rectification procedure (dash lines refer to image quadrilateral).

as "B," "C," and "D" in turn, clockwise around the quadrilateral. Two situations may then arise:

(1) Both image points may lie inside the map quadrilateral and be approximately equidistant from their corresponding map points (2, fig. 96).

(2) One image point may lie much closer to its corresponding map point than the other (7, fig. 96).

c. Completion of Coincidence—First Situation. The situation where both image points lie inside the map quadrilateral and are approximately equidistant from their corresponding map points is treated as follows:

(1) Swing the negative carrier to bring the coincident side parallel to the tilt axis of the easel and the noncoincident points to the front of the easel (3, fig. 96).

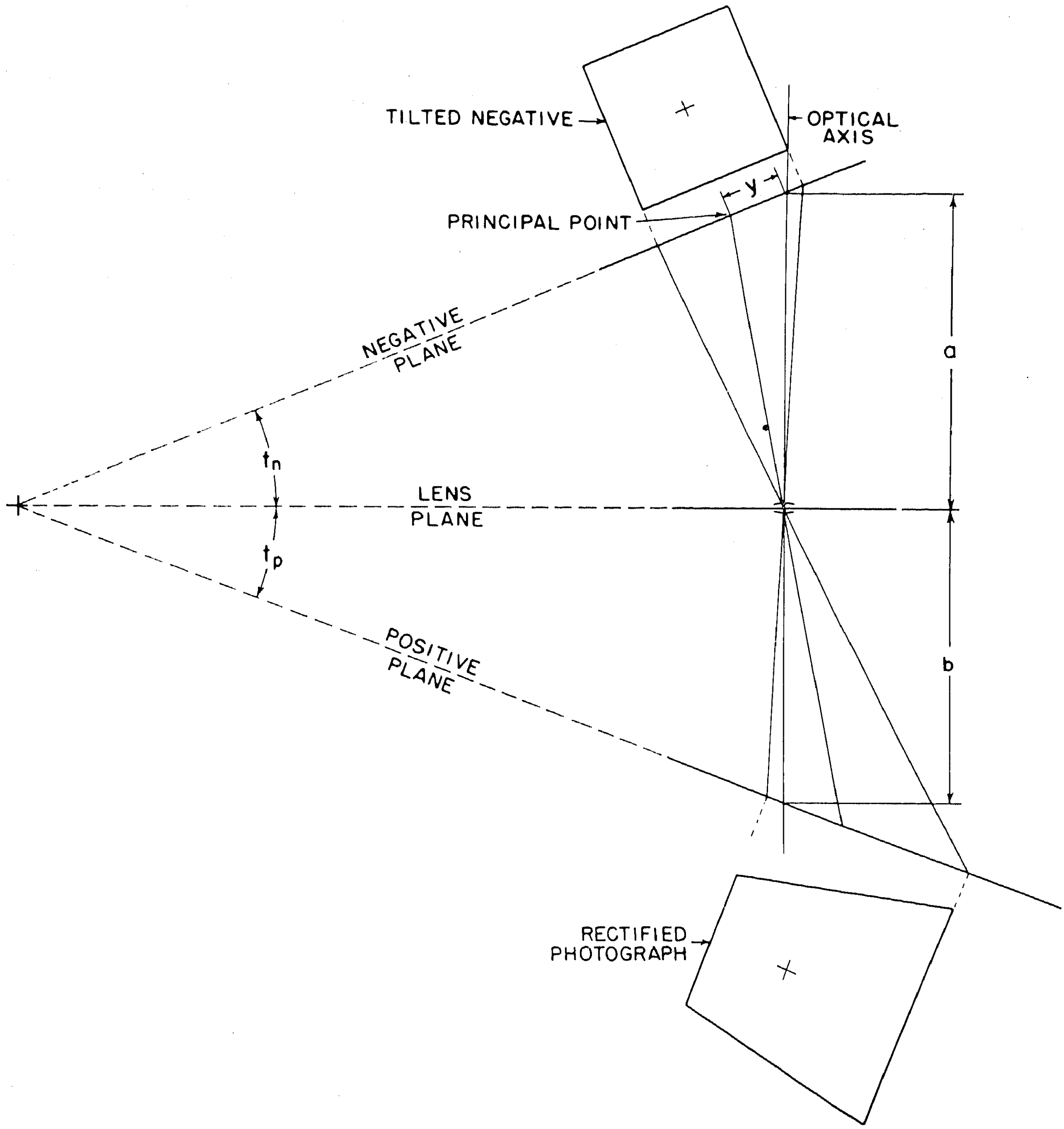


Figure 97. Diagram of geometrical relations of the autofocus rectifier.

(2) Shift the templet and change the magnification as necessary in order to keep the first side in coincidence. It will be necessary to do this after each step during the rectification process.

(3) Bring the remaining points into approximate coincidence by tilting the easel forward and introducing Y-displacement, remembering that tilting the easel changes the convergence of sides "B" and "D" as the images are displaced toward the front of the easel while the Y-displacement changes the lengths of the sides without changing the convergence (4, fig. 96). The sizes of sides "B" and "D" should be constantly compared in order to determine whether the negative needs to be swung. If the image of "D" needs to be shortened, then the swing of the image in a counterclockwise direction will result in displacement of side "D" farther down the tilted easel and thus consequent lengthening (5, fig. 96). If the terrain of the photograph is flat, that is, if all four control points are at equal elevations, then the above steps will result in complete coincidence of the four points. If the terrain is not flat, then the above steps will result in a situation as shown in 5, figure 96, in which the two front points are displaced the same amount laterally in the same direction.

(4) The X-displacement as described causes a shearing of the quadrilateral and the need for X-displacement may therefore be easily recognized when both front image points need to be moved in the same direction approximately as shown amounts to give complete coincidence as shown in 6, figure 96.

d. Completion of Coincidence—Second Situation. The situation where one image point lies much closer to its corresponding map point than the other is treated as follows:

(1) In this situation it is more expeditious to swing the negative so that the diagonal of the quadrilateral which is most nearly coincident is made parallel to the axis of tilt of the easel, and the image point which was inside the quadrilateral is brought to the forward edge of the easel. Shift the templet and change magnification slightly to bring the diagonal image points into coincidence with the map points as shown in 8, figure 96.

(2) Introduce easel-tilt and Y-displacement simultaneously until the front and rear image points are the same distance from their corresponding map points and need only a lateral movement (parallel to the axis of tilt) to bring them into coincidence. If both image points are on the same side of their corresponding map points, then swing is necessary (9, fig. 96).

(3) If the image points are on opposite sides of their corresponding map points, then X-displacement will be necessary (10, fig. 96). A combination of both will probably be necessary to give complete coincidence as in 11, figure 96.

96. Computed Data Method

For the second method of rectification with the autofocus rectifier, use the following equations for computing the various distances and angles as shown in figure 97.

$$\text{Sin } t_p = \frac{f}{F} \sin T$$

$$\text{Sin } t_n = \frac{f}{MF} \sin T$$

$$y = \frac{f \cot t_p}{\cos t_n} - F \cot T$$

$$a = f\ (1 - \cot t_p \tan t_n)$$

$$b = a \cot t_n \tan t_p$$

In which, F = focal length of camera lens
f = focal length of rectifier lens
T = tilt of aerial photograph
M = magnification ratio

APPENDIX I

REFERENCES

1. Army Regulations

AR 117–5	Mapping and Surveying.
AR 320–5	Dictionary of United States Army Terms.
AR 320–50	Authorized Abbreviations and Brevity Codes.

2. Department of the Army Pamphlets

DA Pam 108–1	Index of Army Motion Pictures, Film Strips, Slides and Phono-Recordings.
DA Pam 310–1	Index of Administrative Publications.
DA Pam 310–2	Index of Blank Forms.
DA Pam 310–3	Index of Training Publications.
DA Pam 310–4	Index of Technical Manuals, Technical Regulations, Technical Bulletins, Supply Bulletins, Lubrication Orders, and Modification Work Orders.
DA Pam 310–7	Index of Tables of Organization.

3. Field Manuals

FM 5–188	Engineer Topographic Units.
FM 21–5	Military Training.
FM 21–6	Techniques of Military Instruction.
FM 21–26	Map Reading.
FM 21–30	Military Symbols.
FM 21–31	Topographic Symbols.

4. Technical Manuals

TM 5–230	General Drafting.
TM 5–231	Mapping Functions of the Corps of Engineers.
TM 5–232	Elements of Surveying.
TM 5–234	Topographic Surveying.
TM 5–235	Special Surveys.
TM 5–236	Surveying Tables and Graphs.
TM 5–237	Surveying Computer's Manual.
TM 5–241	The Universal Grid Systems.
TM 5–241–1	Grids and Grid References.
TM 5–241–2	Universal Transverse Mercator Grid Zone to Zone Transformation Tables.
TM 5–241–3/1	Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: International Spheroid (Meters): Volume I: Transformation of Coordinates from Geographic to Grid.
TM 5–241–3/2	Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: International Spheroid (Meters): Volume I: Transformation of Coordinates from Grid to Geographic.
TM 5–241–4/1	Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: Clarke 1866 Spheroid (Meters): Volume I: Transformation of Coordinates from Geographic to Grid.
TM 5–241–4/2	Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: Clarke 1866 Spheroid (Meters): Volume II: Transformation of Coordinates from Grid to Geographic.
TM 5–241–5/1	Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: Bessel Spheroid (Meters): Volume I: Transformation of Coordinates from Geographic to Grid.
TM 5–241–5/2	Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: Bessel

Spheroid (Meters): Volume II: Transformation of Coordinates from Grid to Geographic.

TM 5–241–6/1 Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: Clarke 1880 Spheroid (Meters): Volume I: Transformation of Coordinates from Geographic to Grid.

TM 5–241–6/2 Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: Clarke 1880 Spheroid (Meters): Volume II: Transformation of Coordinates from Grid to Geographic.

TM 5–241–7 Universal Transverse Mercator Grid Tables for Latitudes 0°—45°: Everest Spheroid (Meters): Transformation of Coordinates from Geographic to Grid and from Grid to Geographic.

TM 5–241–8 Universal Transverse Mercator Grid.

TM 5–241–9 Universal Polar Stereographic Grid Tables for Latitudes 79° 30′—90°: International Spheroid (Meters): Transformation of Coordinates from Geographic to Grid and from Grid to Geographic.

TM 5–241–11 Universal Transverse Mercator Grid Tables for Latitudes 0°—80°: Clarke 1866 Spheroid (Meters): Coordinates for 7½-Minute Intersections.

TM 5–241–12 Universal Transverse Mercator Grid Table for Latitudes 0°—33°: Clarke 1866 Spheroid (Meters): Coordinates for 5-Minute Intersections.

TM 5–241–13 Universal Transverse Mercator Grid Table for Latitudes 0°—80°: International Spheroid (Meters): Coordinates for 5-Minute Intersections.

TM 5–241–14 Universal Transverse Mercator Grid Table for Latitudes 0°—80°: Bessel Spheroid (Meters): Coordinates for 5-Minute Intersections.

TM 5–241–15 Universal Transverse Mercator Grid Table for Latitudes 0°—40° 05′: Clarke 1880 Spheroid (Meters): Coordinates for 5-Minute Intersections.

TM 5–241–16 Universal Transverse Mercator Grid Table for Latitudes 0°—40° 05′: Everest Spheroid (Meters): Coordinates for 5-Minute Intersections.

TM 5–243 Cartographic Aerial Photography.

TM 5–244 Multiplex Mapping.

TM 5–245 Map Reproduction.

TM 5–248 Foreign Maps.

TM 30–245 Photographic Interpretation Handbook.

TM 30–246 Tactical Interpretation of Air Photos.

TM 30–252 Photographic Interpretation Manual — Photographic Metrics.

5. Special Publications

American Society of Photogrammetry, Manual of Photogrammetry, 2d Edition.

APPENDIX II

FIELD MAPPING EXPEDIENTS

1. Introduction

In wartime, speed is very important in map making. The quality of a map does not entirely depend on the technique used nor on the source material, but on the ability and experience of the personnel. The following two methods suggest ways in which hasty maps may be made on short notice.

2. Hasty Map and Photomap Backup

This method is most often used for a planimetric map. The normal procedure in producing a line map and photomap backup is to produce a line map first, then lay down a photomap to scale using the line map as a control base. However, when the sheet has to be done in a matter of days, it is much faster to work backward. If the terrain is not too rugged and there are adequate planimetric features, a good semicontrolled photomap can be laid down first. Then all details to make the line map are traced. Even if no photomap backup is necessary, this procedure is still applicable. Furthermore, since one map is a tracing of the other, any grid applied to both maps will have the same coordinates for all features.

3. Single Color Planimetric Maps (1:25,000 Scale)

This map can be made in about 48 manhours of time. This will allow 8 hours for reproducing the map and 40 hours for the compilation and drafting. The source materials are the same as in paragraph 2 above, but the accuracy is the same as that of the uncontrolled photomap.

a. A dry photomap of each flight is first laid down separately. If all the flights are of the same scale, an entire map can be compiled at one time; otherwise, each flight must be compiled individually.

b. The planimetric details are traced onto a plastic overlay. These tracings are changed photographically to drafting scale, and film positives made.

c. Meanwhile, a names overlay, border data, and projection are drawn. The film positive or positives are then paneled to the projection. Scribed sheets can be prepared for final drafting in monochrome or the work can be drafted directly on a separate overlay for reproduction.

4. Maps Used in Close Air Support Operations

For hasty maps prepared at the same scale for the target area phase of close air support operations, the topographic detail should be identical. This is an agreement, in principle, of the Armed Forces of the North Atlantic Treaty Organization. Close air support operations are defined as being air action against hostile surface targets which are so close to friendly forces as to require detailed integration of each air mission with the fire and movement of these forces. For air forces, close air support operations involve two phases. The first is the navigation phase covering the approach to the area where support is required. The second is the target area phase in which actual close air support takes place.

APPENDIX III

MOBILE PHOTOMAPPING TRAIN

1. Introduction

Field photomapping operations of the Army topographic battalion can be efficiently conducted in eleven expansible-type, truck-mounted vans. The Corps topographic company requires only six such vans—multiplex, rectifier, cartographic, map revision, copy and supply, and general purpose photomapping. The battalion is issued one multiplex, one rectifier, and one copy and supply van; two cartographic and two revision vans; and four photomapping vans. The Corps company requires only one of each type. The vans are mounted on a standard ordnance 2½-ton, 190-inch wheelbase truck.

The van body is steel framed. The floor, sides, and roof are constructed of aluminum and plywood with fiberglas insulation. Overall length including the truck is 343 inches; width retracted is 97 inches; width expanded is 168 inches; height is 132 inches. Interior height of the van is 75 inches. It is heated by two gasoline heaters of 60,000 BTU-per-hour capacity, and cooled by an 18,000 BTU-per-hour air conditioner, thereby insuring maintenance of the constant optimum temperature for efficient photomapping. The van is wired for a 120/208 electric system. Power is normally supplied by a trailer-mounted gasoline generator through an inlet receptacle at the rear. Expansion and retraction are easily achieved by manual cranking and manipulation of the roof and floor sections (figs. 98, 99, and 100). Either of the operations may be performed by two persons in about 5 minutes and, if necessary, by one person in about 10 minutes.

2. Multiplex Van Section

The heart of the photomapping train is the multiplex van section, which furnishes the topographic battalion in the field with the means for stereophotogrammetric control extension and compilation. Control extension is accomplished on a double multiplex frame, which can hold 18 projectors, and thereby makes it possible to extend control for long distances (fig. 101).

Map compilation is conducted in two multiplex booths, each equipped with a 32-inch multiplex frame unit consisting of a table, a short frame, and voltage control unit. Three multiplex projectors, a multiplex tracing table, and a drafting stool complete the booth. The two compiling booths provide a capacity of at least 10 square miles per day at a scale of about 1:20,000, when operated in two shifts. When required, this capacity may be trebled by converting the control extension unit into four compiling booths.

In addition to the control extension and compilation facilities, the multiplex van section also has a photographic processing laboratory (fig. 102) which is a darkroom equipped for printing, processing, and indexing multiplex diapositive plates. These multiplex plates are reduced glass replicas of stereoscopic aerial photography. They are used in multiplex projectors to form a stereoscopic model, suitable for direct map compilation. The principal equipment of the laboratory comprises a multiplex reduction printer with accessories, a photographic temperature-controlled sink, a diapositive wash tank, water storage tank, and water pump. The sink is highly versatile. It can automatically heat or cool 1 to 1½ inches of water to temperatures ranging from 50° to 90°F. A heat exchanger, incorporated in the water supply system, heats or cools the water supplied to the diapositive wash tank. This assures control over the temperature of the water to avoid extremes which might cause distortion in the processed plates.

The electric water pump mounted on the floor of the tank, and the 100-gallon water storage tank insure an adequate supply of water for the laboratory. Water may be obtained from open storage or supplied from a pressure system.

Figure 98. Cranking side out for expansion.

Figure 99. Manipulation of roof and floor sections.

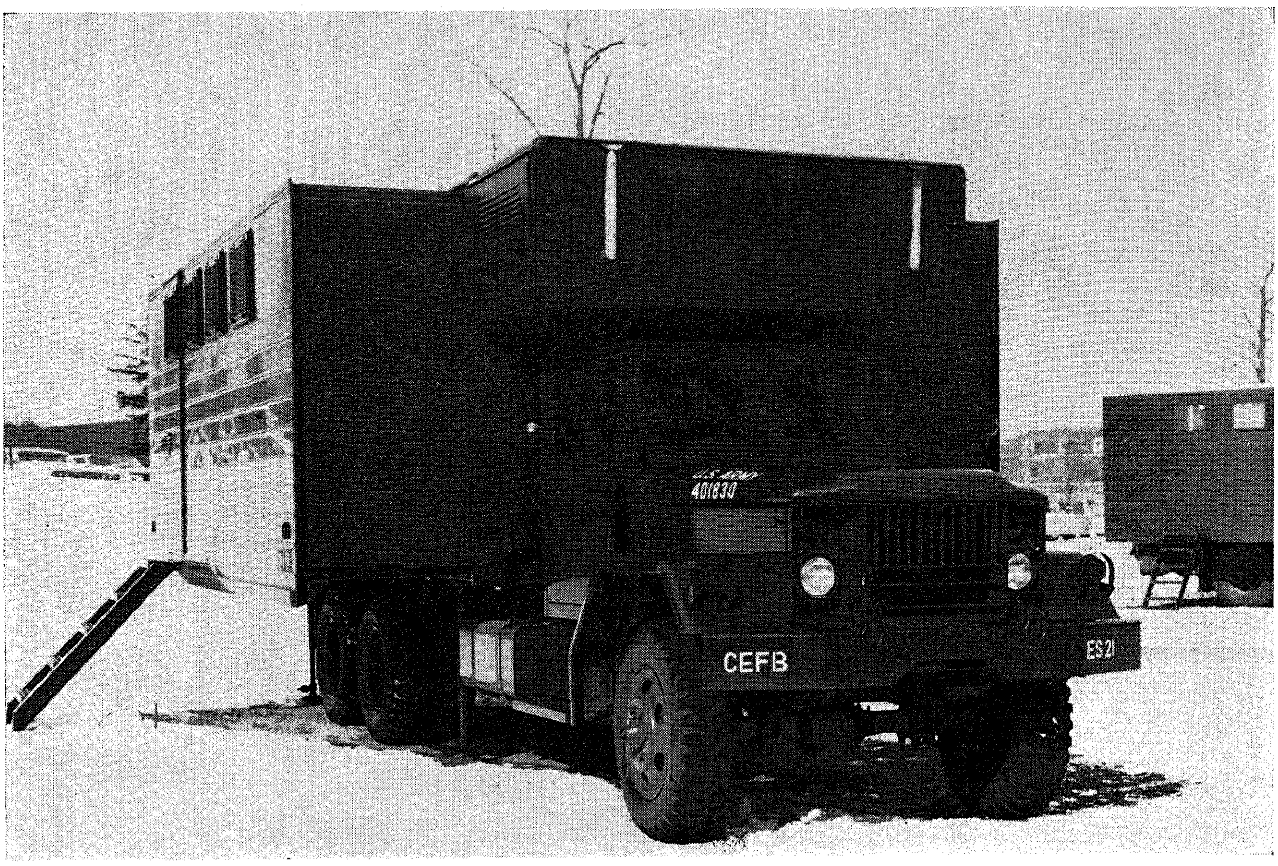


Figure 100. A van of the mobile photomapping train fully expanded.

3. Rectifier Van

The rectifier van permits rectification of tilted aerial photography, and processing of the rectified photographs in lightproof compartments separated by heavy canvas curtains. The autofocus rectifier (fig. 103) can handle 9-by-9-inch aerial photography with tilts from 0° to 35°, and magnification from 0.8 to 3.0. The rectifier is bolted to the van floor for stability and to prevent damage to the instrument while the van is in motion. Like the multiplex van, the rectifier van also has a photographic laboratory for processing rectified and contact prints. A standard Air Force printer and cabinet type print drier are used. The drier consists of an air distribution chamber, 40 horizontal drying racks, and an exhaust chamber through which filtered air is circulated by an electric-motor-driven blower. The racks, made of nylon mesh stretched on aluminum frames, provide a high degree of resistance to fungus and to water absorption. At temperatures of 75° to 80° and relative humidity of 50 to 75 percent, about 160 water-resistant photographic prints (10 by 10 inches) may be dried in about 35 minutes after blotting to remove excess water. No effort is made to heat the air during drying since this might cause differential shrinking or excessive warping.

The water supply system in the rectifier van consists of a temperature-controlled sink with a print washtray mounted over it, a 100-gallon water storage tank, and a water pump. The system can operate by connecting the intake line directly to a pressurized source of supply, or by pumping water out of open storage.

4. Cartographic Van

The cartographic van furnishes the facilities for cartographic work on map manuscripts and for color separation. Originally, this van contained five standard commercial-type drawing table surface illuminated by fluorescent tubes. However, when plastic engraving techniques

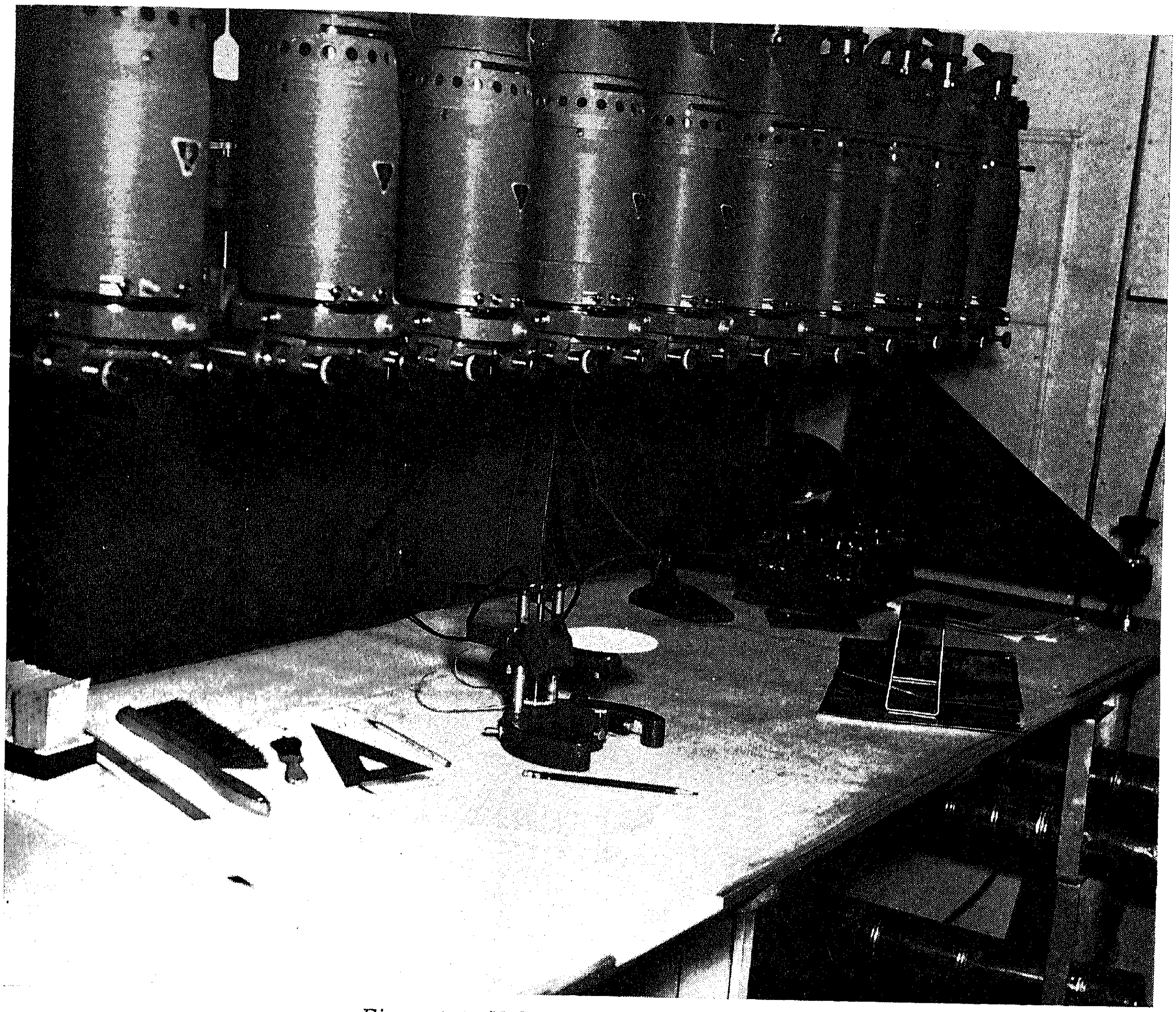


Figure 101. Multiplex setup for operation.

Figure 102. Diapositive printer in multiplex van.

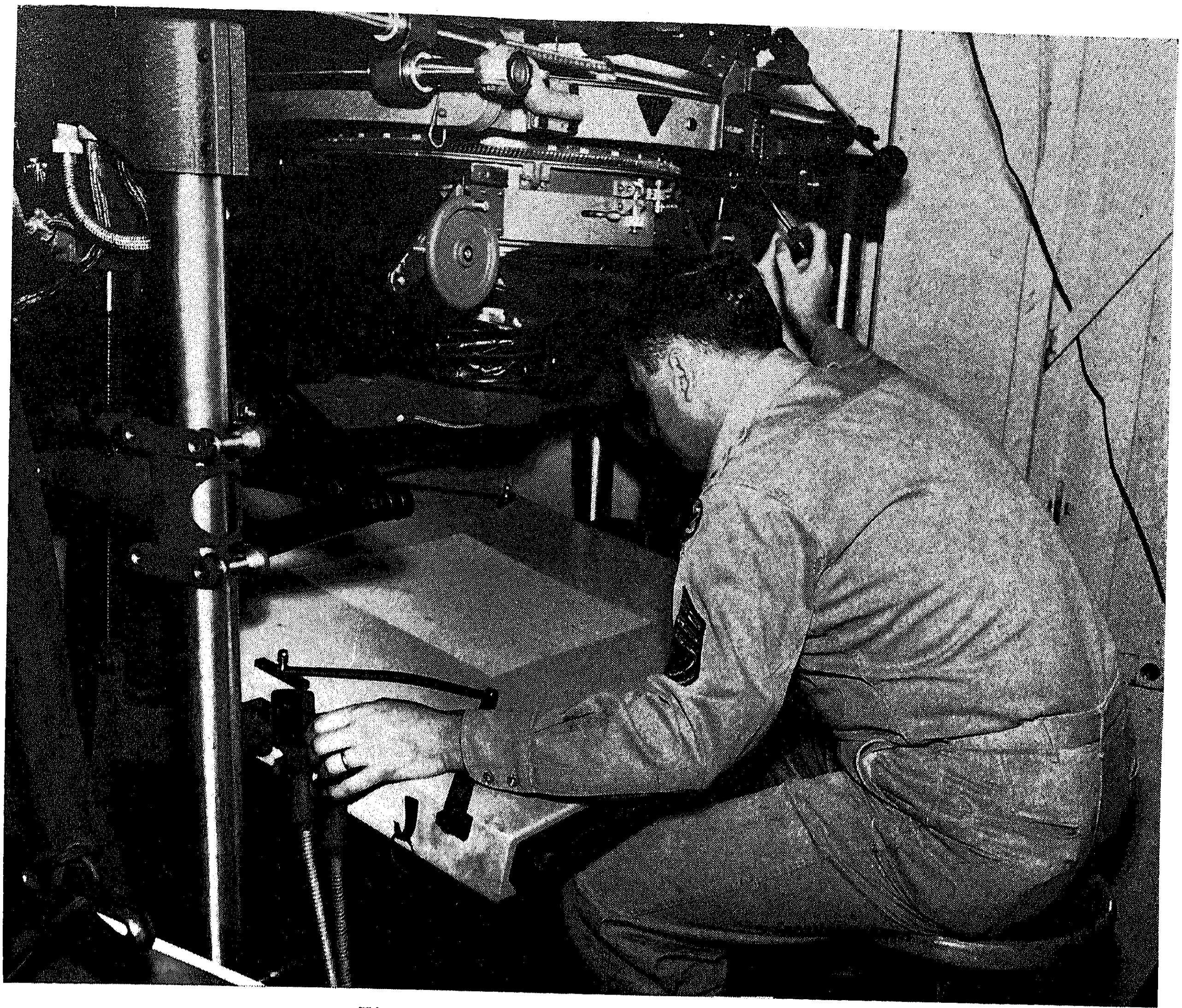


Figure 103. Autofocus rectifier in operation.

were adopted, the van was appropriately re-equipped. A drawing and engraving table was developed and some modifications were made in the van to accommodate five such tables. They are standard drawing tables modified by the insertion of an aluminum light box into an opening in the table drawing board. The light box has two 15-watt fluorescent tubes with fittings and a block of methy methacrylate, and is covered by a 15-by-15-inch plate glass top that fits flush with the drafting surface of the table. The light table has an intensity of illumination ranging from 84 to 155 foot-candles.

5. Map Revision Van

Equipment mounted in the map revision van comprises a 60-by-120-inch drawing board for layout, supported on a framework of 2-inch aluminum angles, a vertical autofocus reflecting projector, and a steel storage cabinet. There is a blackout curtain around the reflecting projector, thereby permitting independent operation. In addition there are the following instruments: a vertical sketchmaster, an oblique sketchmaster, three stereometers (stereocomparagraph type) and three parallel motion protractors. Drafting stools, fluorescent desk lamps, and miscellaneous items of drafting equipment complement the furnishings.

6. Copy and Supply Van

The copy and supply van is principally geared for reproduction of transparencies by means of an ammonia process printing and developing

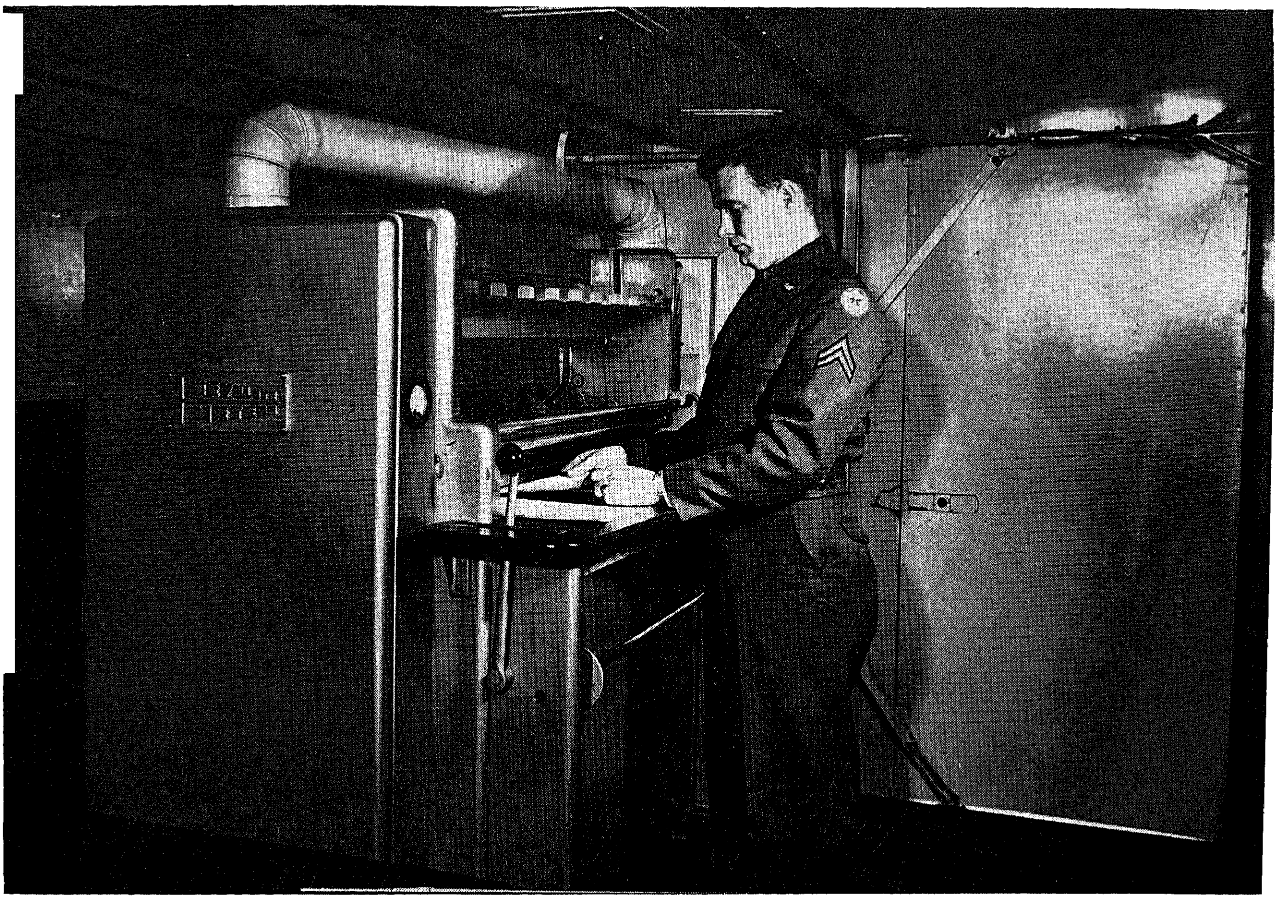


Figure 104. Ammonia process and printing machine in copy and supply van.

machine (fig. 104). This machine is a standard commercial product and can produce quality contact prints in cut-sheet or roll form up to 42 inches in width. The machine is vented to the outside of the van to prevent a concentration of ammonia fumes on the inside. This van also provides storage space and cabinets for the innumerable items of equipment and supplies needed in the operation of the photomapping train for a period of about 30 days.

7. General Purpose Photomapping Van

The general purpose van contains a mounted 60-by-120-inch drawing board, a standard commercial drawing table, a drawing and tracing table and various metal cabinets for filing of manuscripts and storage of supplies.

The photomapping train provides the long looked for capability of tremendous mobility and almost instantaneous operation upon arrival at a destination.

APPENDIX IV

COMPILATION RECORD SHEET

The compilation record sheet furnishes the compiler with basic information about the source material, and with recommendations as to its use. The suggestions and evaluations reflect the purpose for which the map is intended and should be followed carefully.

SAMPLE

SERIES: V501
SERIES NAME & SCALE: Eastern U.S. 1:250,000
SHEET NO: NI 18–4

JOB CONTROL NO: 22501–087
DATE: 1 June 1960
AUTHOR: J. Doe

I. SOURCE MATERIAL & EVALUATION

A. Maps
   Title
   Authority
   Reliability
   Credit Note Date

B. Other Sources
   Atlases
   Charts
   Miscellaneous

II. RECOMMENDATIONS

A. Cartographic
   Base
   Photography
   Control
   Hydrography
   Relief
   Roads
   Railroads
   Boundaries
   Populated Places
   Names
   Aerodromes
   Vegetation

B. Photogrammetric
   Basic Reference Material
   Hydrography
   Relief
   Roads
   Railroads
   Boundaries
   Populated Places
   Names
   Aerodromes
   Vegetation

III. BACK-UPS
(if required)

APPENDIX V

EDIT CHECKLIST

The edit checklist offers a detailed series of items to check the copy (ch. 5), whether compilation, color separation, or revision for completeness and accuracy. The items are in a sequence which may not follow the operation procedure, but the entire list must be checked and initialed.

SERIES .... SHEET NUMBER ...... DATE ....
WORK ORDER .... SHEET NAME ....

/here corrections are to be made, they will be indicated on REGISTERED TRACING PAPER OR ON OPIES.

ITEM CHECKED	EDITOR'S INITIALS
1. PROJECTION	
a. Accuracy of projection	....
b. Accuracy of divisions	....
c. Coordinates correct	....
d. Sheet lines match detail	....
e. Match with adjoining sheets	....
f. Projection note	....
g. Draftsmanship	....
2. GRID AND GRID DATA	
a. Accuracy of grid	....
b. Accuracy of grid divisions	....
c. Numbering of grid	....
d. Match with adjoining sheets	....
e. Grid declination	....
f. Magnetic declination	....
g. Protractor scale	....
h. Grid data note	....
i. Reference note	....
j. Draftsmanship	....
3. SCALES	
a. Accuracy of scales	....
b. Type	....
c. Location	....
d. Draftsmanship	....
4. REPRODUCTION BLOCKS	
a. Check reduction or enlargement blocks	....
b. Check to insure fit on sheet specified	....
5. TOP MARGIN	
a. Series and scale	....
b. Classification note	....
c. Sheet name	....
d. Edition number	....
e. Sheet and series number	....
f. Refer to this sheet as: note	....
g. Identification panel	....
6. SIDE MARGINS	
a. Glossary	....
b. Index to adjoining sheet diagram	....
c. Reliability diagram	....
d. Index to boundaries diagram	....
e. Draftsmanship	....
f.	....
g.	....
7. BOTTOM MARGIN	
a. Series and edition numbers	....
b. Credit note	....
c. Legend	....
d. Scale note and bar scales	....
e. Projection and grid notes	....
f. Contour interval note	....
g. Horizontal, vertical and hydrographic datum notes	....
h. Omitted digits note	....
i. User's note	....
j. Declination diagram and note	....
k. Index to boundaries diagram	....
l. Coverage diagram	....
m. Reliability diagram	....
n. Index to adjoining sheets diagram	....
o. Country name block	....
p. Glossary	....
q. Identification panel	....
r.	....
8. GENERAL	
a. Balance of marginal data and compliance with style sheet	....
b. Size and style of stickup or lettering	....
c. Route objectives for major roads	....
d.	....
e.	....
9. CULTURAL FEATURES	
a. Airfields and aids to air navigation	....
b. Aqueducts and pipelines	....
c. Bridges	....
d. Canals and ditches	....
e. Cemeteries	....
f. Civil boundaries	....

ITEM CHECKED	EDITOR'S INITIALS
g. Control data	....
h. Dams	....
i. Ferries and fords	....
j. Furnaces, smelters and coke ovens	....
k. Levees, seawalls, cuts, fills and mine dumps	....
l. Lighthouses and aids to navigation	....
m. Located objects and their labeling	....
n. Mines, shafts and quarries	....
o. Oil, gas and water wells and tanks	....
p. Power transmission lines	....
q. Railroads, various gauges and conditions	....
r. Reservoirs	....
s. Roads, alinement and classification	....
t. Telephone and telegraph lines	....
u. Tunnels	....
v. Wharves, piers, jetties and breakwaters	....
w.	....
x.	....
10. RELIEF FEATURES	
a. Contour interval	....
b. Strength of contour lines, index and intermediate	....
c. Cliffs, scarps and faults	....
d. Depressions	....
e. Contour numbers	....
f. Spot elevations	....
g. Shaded relief	....
h. Logical land conformation	....
i.	....
j.	....
11. DRAINAGE FEATURES	
a. Glaciers	....
b. Lakes, perennial and intermittent	....
c. Streams, perennial and intermittent	....
d. Marshes	....
e. Submerged or partially submerged areas	....
f. Rapids and falls	....
g. Rocks and boulders	....
h. Shore lines, natural and manmade	....
i. Sand, foreshore and offshore	....
j. Springs, water or mineral	....
k. Wells and water tanks	....
12. VEGETATION OR WOODLAND FEATURES	
a. Woodland area	....
b. Orchards and vineyards	....
c. Clearings for roads, railroads and other manmade objects	....
d. Brush and brushwood	....
13. NAMES, TITLES AND LETTERING DETAIL	
a. Selection and spelling	....
b. Locality names	....
c. Adequacy of features named	....
d. Names for located objects and landmark objects	....
e. Punctuation and diacritics	....
f. Positioning	....
g. Abbreviations	....
h. Lettering style and composition	....
i. Neatness	....
14. DRAFTSMANSHIP	
a. General appearance	....
b. Line weights	....
c. Symbolization	....
d. Color separation	....
e. Suitability as photographic copy	....
15. REGISTER	
a. Corner ticks	....
b. Centerline registration, culture plate	....
c. Clarity of map with all colors registering	....
d. Detail match with adjoining sheets	....
16. REMARKS	
a.	....
b.	....
c.	....
d.	....

APPENDIX VI

SLOTTED TEMPLET CONTROL EXTENSION WITH 36-INCH FOCAL LENGTH CAMERA

1. Background

a. Aerial Photo Coverage. Photography is aken at an altitude of 34,000 feet with 36-inch focal length cameras. Thirty-six-inch focal length, 9- x 18-inch format, fan mount photographs are used. Three cameras are utilized in obtaining the 36-inch focal length photography; one vertical and two oblique at an angle of approximately 19° from the vertical. All oblique photographs are normally rectified for use in construction of the slotted templets. The standard templet slot cutter is used to cut the radial centers and all the slots for the templets. If practical, the cameras are alined and mounted so that the camera axes and the fiducial markers in their 9-inch format sides are all contained in a plane. It is essential that the cameras be rigidly mounted with respect to each other to provide three to six degrees side lap, be exposed simultaneously, and that forward lap be sufficient to allow triangulation (B/H ratio 0.12 to 0.06).

b. Templet Material. Templets are made of "Bristol" board to appropriate size.

c. Plotting Board. A "Masonite" plotting board 8 x 8 feet in size is used. This plotting board is painted a flat white to aid in the location of points when the grid sheet is placed on it.

d. Scale of Plots. A plot scale of 1: 10,000 is used for the 36″ FL photography.

e. Grid Sheet. A master grid sheet is constructed with a precision coordinatograph on a stable-base translucent plastic sheet. This sheet is used in plotting the starting and ending horizontal control on the plotting board and later as an overlay sheet in checking the positions of the checkpoints determined from the plots. A centerline is drafted on the plotting board to help aline the grid overlay sheet, containing the starting and ending control, to its correct position on the plotting board.

f. General Procedures. Slotted templets are made directly from the 36-inch focal length, 9- x 18-inch format, vertical, and oblique photos, and the templets are assembled to establish control points for the 36-inch focal length photography.

2. Method

A graphical method is utilized to obtain sufficiently accurate secondary control for laying a controlled mosaic using only the 36″ FL photography, when the 6″ FL photography may not be suitable or available, and since the points for supplementary control are too crowded on the 6-inch photos.

a. Graphic.

(1) Vertical photos are prepared in the conventional manner with identification of principal points, pass points, and two horizontal control points at each end of the strip. It is evident from a laydown of the vertical 36″ FL photos that tip, tilt, and possibly some swing are present in most of the photos. The interlocking angles between the oblique cameras and the vertical cameras are computed as shown in figure 105. Random pairs of contact prints of vertical and left oblique, and of vertical and right oblique, are measured and the interlocking angles are averaged to compute the normal tilt.

(2) The longer focal length makes departures of the vertical camera principal points from the nadir points larger, due to tilt, consequently an effort is made to locate the nadirs in a more precise manner. The pictures are matched in groups of three and a mean line drawn through the principal points. This is considered to be approximately normal to the aircraft "track" and therefore the nadirs are chosen along this line midway across each picture. The displacement dis-

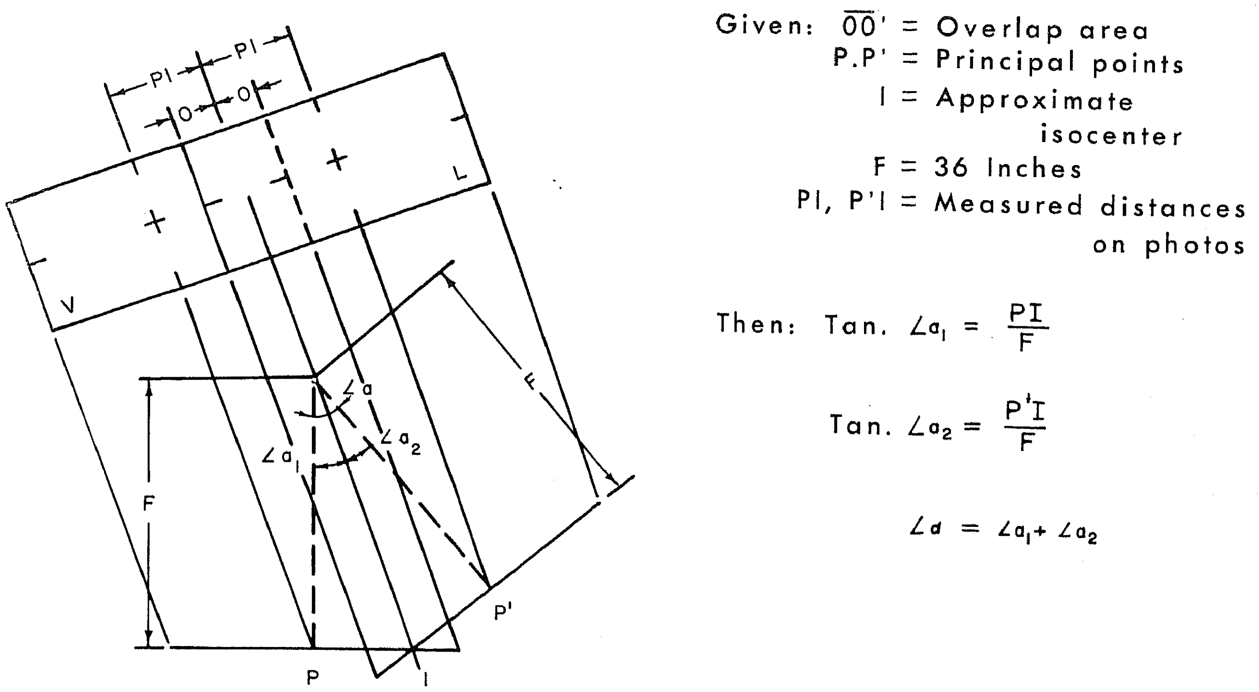


Figure 105. Tilt angle determination for 36-inch FL photos.

tances of the nadir points from the principal points are tabulated.

(3) Photo points common to the vertical photos and the rectified wing photos are transferred to the wing photos (fig. 106). Additional photo rectification points and a horizontal control point at each end of the wing strips are pricked at the outer edge of the nominally rectified photos.

b. Limitations of 36-Inch Photography. There are limitations on the use of 36-inch photography. Because of the photo scale it is difficult to transfer points. A problem of relief is also presented; it does not show relief clearly or consistently.

(1) The distances from the nadir points to the principal points for the wing photos are computed from the nadir distance used for rectification and the tabulated increments for the displacement of the nadir points from the principal points previously found for the vertical photos. Tabulation of these corrected distances is made for use in the construction of the wing templets.

(2) First, templets for the vertical photos are made by taping them fast and pricking the points through to the templet material. The nominally rectified wing photos are taped fast to ad-

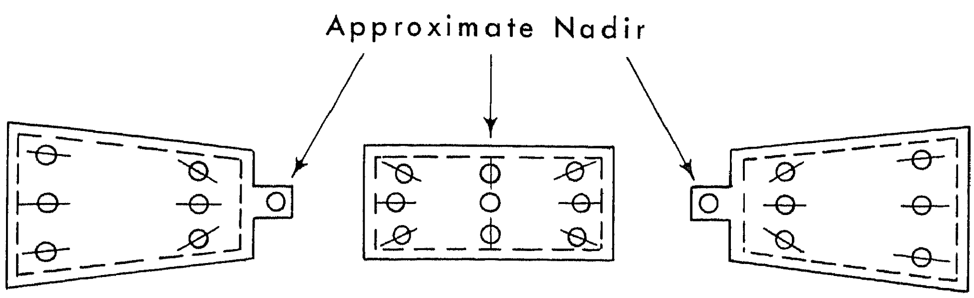


Figure 106. Templets for 36-inch FL plot.

ditional templet material and the points are pricked through. The fiducial axes of the left wing and of the right wing photos are assumed to be alined to the cross flight fiducial axis of the vertical photo. The location of the nadir point for the templet is found by alining a straight edge of the principal and fiducial points of the wing photo and drawing a line extending well out past the edge on the photo in the direction of the nadir. Then the corrected nadir distance for that photo is scaled and the point pricked on the line. Rays are drawn from this nadir position through all the photo points pricked from the wing photo. The radial center and all the slots for each templet are cut on the standard templet slot cutter.

c. Horizontal Control. The grid sheet containing the plotted horizontal control is alined to the plotting board such that the starting control just falls on the board (fig. 107). All of the control points are then pricked and labeled in proper sequence.

d. Slotted Templet Plot. Studs and pins are affixed to the starting and ending control points on the board (fig. 107). The vertical templets are assembled and adjusted to their four control points. Then the oblique photo templets are laid with the extensions containing the nadirs also at the radial centers. The templets from the left wing photos may require adjustment to obtain the best fit. Laying the wing templets greatly helped to strengthen the azimuth of the vertical plot. After the templets are adjusted to control and to one another, pins are hammered through studs transferring the plot positions to the plotting board. Pins locating the points are left on the board until all the points are correctly labeled. The grid overlay sheet is oriented to its proper position on the board and the points are pricked thereon. Northing and Easting distances are scaled for a comparison with the true values for the checkpoints.

3. Discussion

a. As in the case of the split vertical photography, it is necessary to precisely determine the angles between the oblique cameras and the vertical camera. It is also necessary that the fiducial marks in the short sides of the oblique camera formats be contained in the principal plane of their respective vertical-oblique camera combination and, further, the two principal planes should be as nearly coincident as possible. This makes more nearly valid the assumption that the nadir point lies on an extension of the oblique camera fiducial axis.

b. By matching adjacent vertical pictures and transferring principal points, a mean flight line is found. This improves the nadir point selection and also discloses unusual tilts across the line of flight because the extent of deviation indicates the amount of tilt. Special rectification of these photographs and use of the mean flight line for nadir point location makes templet laying easier. It is pointed out that tie points between oblique and vertical photos are selected near the isocenters of the obliques. A step-by-step procedure for graphical aerotriangulation with 36-inch focal length, fan-mount photography is contained in paragraph 5 of this appendix.

4. Conclusions

a. Precise determination of interlocking angles is necessary for preparation of rectified prints of oblique photographs from which slotted templets are to be made.

b. Establishment of supplementary control from 36-inch "fan" photography by the slotted templet method is practical.

5. Step-by-Step Procedure

a. Determine the interlocking angles between the oblique cameras and the vertical camera.

b. Using the interlocking angle as the tilt of the respective oblique camera, nominally rectify the oblique photography.

c. Matching vertical photo to photo, establish a smooth line that passes most nearly through the principal points of the vertical photographs.

d. If a principal point is found to be off the mean nadir line more than about 0.75 inch, the oblique photos should be rerectified using corrected angles as indicated from the departure from the mean nadir line. The correction is equal to the angle subtended by the departure, in inches, at 36 inches.

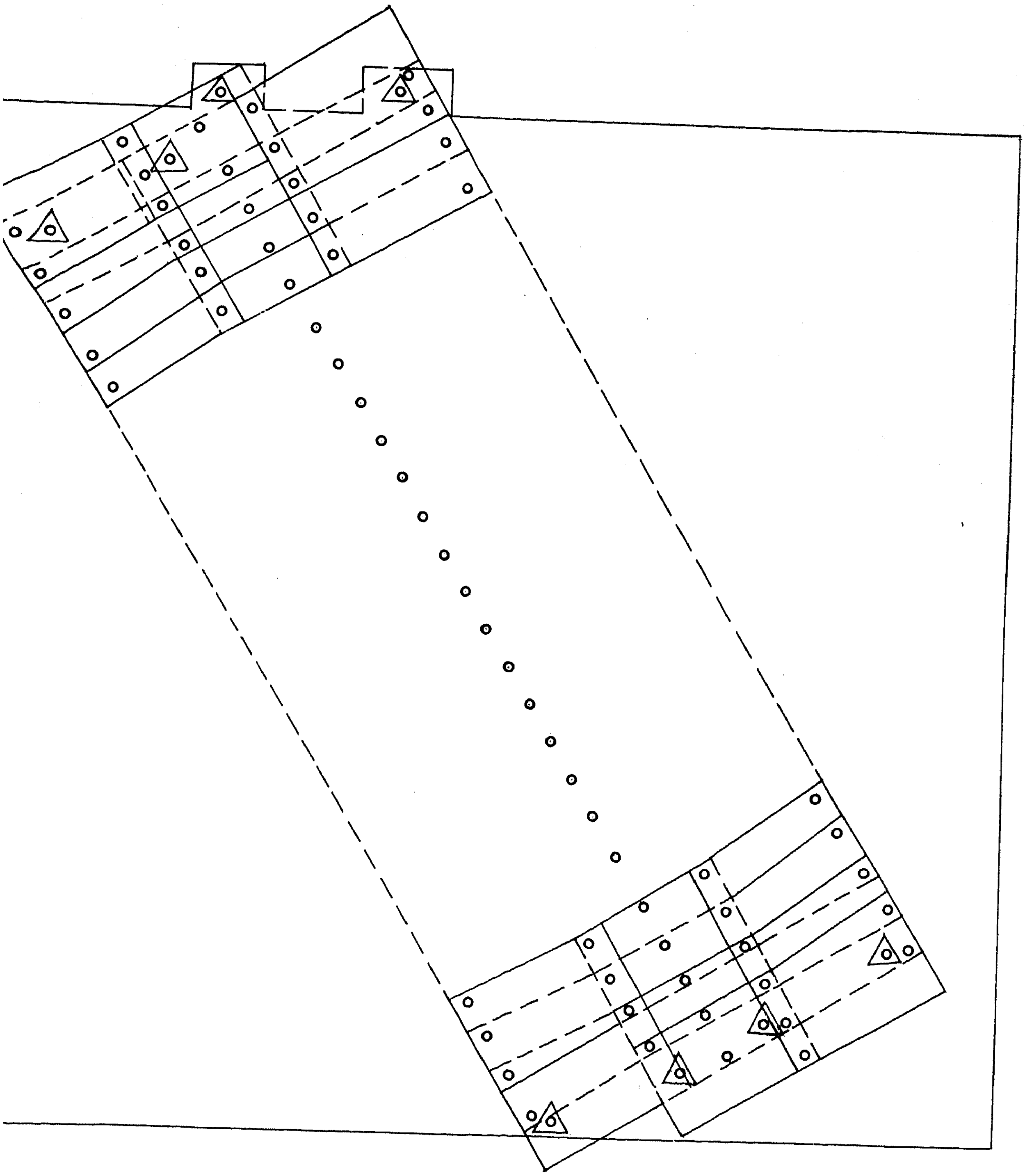


Figure 107. Templet assembly on plotting board.

graphically, by means of maps and charts, the known physical features of the earth's surface and the works of man and his varied activities.

Cassini-Soldner projection—Similar to polyconic and used by the British where the United States would use polyconic. Best adapted for north-south belts and large-scale maps of small areas. Its principal difference from polyconic is that it uses but one central meridian for a whole series.

Central meridian—The line of longitude occupying the center of a projection. Generally the basis for constructing the projection.

Classification survey—The process of comparing aerial photographs with conditions as they exist on the ground and of obtaining information to supplement or clarify that which is not readily discernible on the photographs themselves.

Color separation—Separation or isolation of the several colors of an original copy into individual images. Scribed plastic sheets prepared individually for specific colors become separation negatives. Photographs of these blueline boards produce color separation negatives.

Compilation—The process of extracting map detail from aerial photographs and/or other sources, to fit a control network in the preparation of a map.

Composite print—Reproduction from a successive series of images. A proof made by exposing the negatives of color-separation boards one after the other on a single sheet of black and white or blueprint photo paper which when developed "composes" or contains the images of all the negatives on a single sheet. Used in checking and editing.

Contour—An imaginary line connecting the points on a land surface that have the same elevation; also the line representing this on a map.

Contour interval—The constant difference in elevation between successive contours.

Contour map—*See* Map.

Control—A system of relatively accurate measurements to determine the distances and directions or differences in elevation between points on the earth, upon which depends a system of lesser accuracy.

Astronomic control—Control established by observation upon heavenly bodies.

Geodetic control—Control which takes into account the size and shape of the earth; i.e., system of points of known latitude, longitude, and elevation.

Ground control—Control obtained by ground surveys as distinguished from control obtained by photogrammetric methods.

Horizontal control—Control which determines horizontal positions only, as with respect to parallels and meridians or to other lines of reference.

Multiplex control—Control established from other existing control by bridging or by cantilever extension with the multiplex projectors.

Recovered control—Control previously established from other sources, which can be identified.

Vertical control—Control which determines position with respect to elevations only.

Control point—Any station in a horizontal and/or vertical control system that is identified on a photograph and used for correlating the data shown on it.

Controlled mosaic—*See* Mosaic.

Coordinates—Linear or angular quantities (usually two-dimensional) which designate the position which a point occupies in a given reference plane or system.

Grid coordinates—A plane rectangular coordinate system based upon, and mathematically adjusted to a map projection in order that geographic positions (latitudes and longitudes) readily may be transformed into plane coordinates and the computations relating to them by the ordinary methods of plane surveying.

Plane coordinates—A system of coordinates in a horizontal plane, used to describe the positions of points with respect to an arbitrary origin by means of two distances perpendicular to each other. (Linear quantities.)

Rectangular coordinates—Same as plane coordinates, sometimes called *plane rectangular coordinates.*

Culture—Those features of terrain that have been constructed by man, such as roads,

trails, buildings, and canals; also boundary lines and all names and legends.

Datum—A referenced element, such as a line or plane, in relation to which the positions of other elements are determined.

Dip angle—The angle between the apparent horizon and the true horizon.

Direction of tilt—The direction (azimuth) of the principal plane of a photograph.

Domestic map—A map of an area within the limits of the United States.

Editing—The process of checking a map in its various stages of preparation to insure correct preparation from and interpretation of the sources used, and assure legible and precise reproduction.

Elevation—Vertical distances above the datum, usually mean sea level, to a point or object on the earth's surface.

Equator—An imaginary line around the earth which is everywhere equidistant from the poles.

Fiducial marks—Index marks rigidly connected with the camera lens through the camera body and forming images on the negative which define the principal point of the photograph.

Film negative—A negative made on film, as contrasted to a glass negative (*See also* Negative.)

Film positive—A film on which the image of the original object corresponds to the same in the scheme of light and shade.

Firebreak—A strip through woodlands from which trees and underbrush have been cut to impede the progress of forest fires.

Flight altitude—The vertical distance above a given datum of an aircraft in flight, or during a specified portion of a flight. The datum usually is mean ground elevation.

Flight line—A line drawn on a map or chart to represent the track over which an aircraft has been flown, or the course over which it is to be flown.

Flight map—*See* Map.

Floating mark—A mark seen as occupying a position in the three-dimensional space formed by the stereoscopic fusion of a pair of photographs, and used as a reference mark in examining or measuring the stereoscopic model.

Focal length—Perpendicular distance between the image plane and the rear node of the lens when the lens is set to project light rays from infinity.

Focal plane—The plane perpendicular to the axis of the lens in which images of points in the object field of the lens are focused.

Foreshore—That area which is bare or awash at low tide, but covered at high tide.

Form lines—Lines having the same appearance as contour lines but which have been sketched from visual observation to show the shape of the terrain rather than its elevation.

Forward lap—*See* Overlap.

Foul ground—Any area which is shoal, but covered at low tide.

Gazetteer—A list of place names usually giving the geographic locations and grid references of the places listed. AMS gazetteers are based on one or several related map series.

Geodetic control—*See* Control.

Great circle—The largest circle that can be drawn through any given point on the globe.

Greenwich meridian—The meridian passing through Greenwich, England, and designated as the zero or standard meridian on maps made in Britain, the United States, and many other countries.

Grid reference box—A box appearing in the map's margin containing instructions for determining grid references.

Grid system—(1) A systematic network of lines on a plane surface upon which coordinates are based and to which the map features are references.

(2) A rectangular network of lines on a *map projection.*

Grid coordinates—*See* Coordinates.

Grid values—Numbers appearing in the margin of and on the face of a map labeling grid lines. Those in the margin at the southwest corner are complete; the others are abbreviated.

Grid zone—A column, 6° in latitude, whose grid coordinates are based on the same origin. In the Universal Transverse Mercator Grid system, the zones are numbered from 1 to 60, beginning at 180° and progressing eastward.

Ground control—*See* Control.

Ground survey—*See* Survey.

High-oblique photograph—An oblique photograph which shows the horizon.

Aeronautical map—See aeronautical chart.

Battle map—A map suitable for the tactical and technical needs of all arms.

Contour map—A topographic map which portrays relief by means of contour lines.

Flight map—A map on which are indicated the desired lines of flight for a photographic mission.

Photomap—The reproduction of a single photograph, composite, or mosaic, complete with grid lines and marginal data.

Planimetric map—A map which presents only the horizontal positions for the features represented; distinguished from a topographic map by the omission of relief in measurable form.

Reconnaissance map—A map prepared from a reconnaissance survey. (*See also* Reconnaissance.)

Strategic map—A topographic or planimetric map used for planning operations, including movements, concentration, and supply of troops.

Tactical map—A topographic map for general field use and tactical and logistic studies by units from corps to regiment.

Topographic map—A map which presents the horizontal and vertical positions of the features represented; distinguished from a planimetric map by the addition of relief in measurable form.

Map plane—Any horizontal plane to which the planimetry and relief of an area are plotted or referenced.

Map projection—See Projection.

Marginal data—Information in the margin of maps which is of aid in filing the maps, in interpreting them, and in determining their accuracy, as well as for general information.

Mechanical-arm templet—See Templet.

Model—See Stereoscopic model.

Mosaic—An assembly of two or more overlapping aerial photographs. Also called *aerial mosaic.*

Controlled mosaic—A mosaic fitted to a control plot by rephotographing the component vertical photographs to compensate for scale variations resulting from tilt and for variations in flight altitude.

Uncontrolled mosaic—An assembly of two

Horizon:

Apparent horizon—The apparent or visible junction of earth and sky as seen from any specific position. Also called *visible horizon.*

True horizon—A horizontal plane passing through a point of vision or perspective center.

Horizon trace—An imaginary line on the plane of the photograph which represents the image of the true horizon.

Horizontal control—See Control.

Horizontal control point—A control point in a horizontal control system. (*See also* Control point.)

Horizontal parallax—See Parallax.

Hydrographic chart—A chart showing water depths, islands, channels, the conformation of the sea or lake bottom, and aids and menaces to navigation. It also shows the typography of the shore and as much of the land's salient features as would serve the navigator as landmarks.

Hydrographic datum—The plane of reference of soundings, depth curves and elevations of foreshore and offshore features.

Hypsography—Parts of a map, such as contours and contour values, which represent relief.

Isocenter—The point on a photograph intersected by the bisector of the angle between the plumb line and the photograph perpendicular.

Kelp—A marine vegetation generally growing in areas of rocky bottoms. In exposed waters kelp may grow in depths of 9 to 10 fathoms and in protected waters in even deeper depths. In certain areas its presence is the only indication of submerged pinnacles.

Low-oblique photograph—An oblique photograph with the entire picture below the horizon.

Loxodrome—See Rhumb line.

Manuscript map—The original drawing of a map as compiled or constructed from various data such as ground surveys and photographs.

Map—A representation on a plane surface, at an established scale, of the physical features —natural, artificial, or both—of a part of the whole of the earth's surface by means of signs and symbols, and with the means of orientation indicated.

or more overlapping vertical photographs assembled only by matching photographic detail without the benefit of a framework of control points.

Strip mosaic—An assembly of a strip of vertical photographs taken in a single flight.

Mosaic index—A small-scale reproduction of a mosaic which serves as a guide to the individual photographs and which may be used for planning mapping projects.

Multiplex—A stereoscopic plotting instrument used in preparing topographic maps by stereophotogrammetry.

Multiplex control—*See* Control.

Multiplex extension—The extension of a strip of photographs by stereophotogrammetric methods. (*See also* Cantilever extension; Multiplex triangulation.)

Multiplex model—An optical projection of two overlapping images in complementary colors by means of the multiplex projectors, which gives a stereoscopic image when viewed through spectacles having filters of corresponding complementary colors.

Multiplex projector—An instrument which forms a part of the multiplex equipment and which projects a reduced copy of the aerial negative.

Multiplex tracing table—A piece of multiplex equipment used for viewing the stereoscopic model, measuring the elevations in it, and compiling the detail on a map plane.

Multiplex triangulation—*See* Triangulation.

Nadir—That point on a celestial sphere directly beneath the observer and directly opposite to the zenith. *Photograph nadir* (or *nadir point*): That point at which a vertical line through the perspective center of the camera lens pierces the plane of the photograph.

Neatline—The line which surrounds the map itself. The margin is outside the neatline.

Negative—A sensitized plate or film which has been exposed in a camera and which has the lights and shades in inverse order to those of the original subject.

Nipa swamp—A swamp whose trees are trunkless palms. Grows on ground which is covered at high tide, usually only one to two feet. Channels through nipa swamp are generally navigable, and foot movement in other areas is less difficult than in mangrove swamp.

Oblique photograph—A photograph taken with the camera axis directed intentionally between the horizontal and the vertical.

High oblique—An oblique photograph in which the apparent horizon is shown.

Low oblique—An oblique photograph in which the apparent horizon is not shown.

Orientation:

Relative orientation—(1) The reconstruction of the same perspective conditions between a pair of photographs which existed when the photographs were taken.

(2) The orientation of one multiplex projector with reference to another to produce the relative relationships of the taking camera.

Absolute orientation—The fixation of scale, position, and orientation of the stereoscopic model produced by relative orientation with reference to the ground coordinates. A multiplex model with correct scale and horizontalization is an absolute orientation.

Orthographic projection—*See* Projection.

Overlap—Amount by which one photograph overlaps the area covered by another, customarily expressed as a percentage.

Forward lap—The overlap between two photographs in the same flight.

Side lap—The overlap between photographs in adjacent parallel flights.

Overlapping pair—Two photographs taken at different exposure stations in such manner that a portion of one photograph shows the same terrain shown on a portion of the other photograph.

Overlay—A record on a transparent medium to be superimposed on another record.

Paneling negatives—Cutting a film negative in which some distortion is involved, into several pieces and cementing them in place, on a projection drawn on vinylite, in such a way that the error is distributed in small amounts throughout the area rather than being localized.

Parallax—The apparent displacement of the position of a body with respect to a reference point or system, caused by a shift in the point of observation.

Absolute parallax—Considering a pair of truly vertical photographs, of equal

principal distances, taken from equal flight altitudes; or a pair of rectified photographs; or a stereoscopic model formed by the multiplex projectors of such photographs: the absolute parallax of a point is the algebraic difference, parallel to the base line, of the distances of the two images from their respective principal points. It is a measure to scale of the height of the image in space.

X-parallax or horizontal parallax—Synonymous with *absolute parallax,* and also used in multiplex operations to denote the component of distance between the corresponding images of a point in a stereoscopic model in a direction parallel to the vertical plane containing the base line when that model is intercepted by a horizontal plane, such as the platen of the multiplex tracing table.

Y-parallax or vertical parallax—The difference of the perpendicular distances of the two corresponding images of a point in overlapping photographs or projections of photographs from the vertical plane containing the base line.

Pass point—A point the horizontal and/or vertical position of which is determined from photographs by photogrammetric methods, and which is intended for use after the manner of a ground-control point in the orientation of other photographs.

Perspectives—The two-dimensional appearance of the object with reference to the point of observation.

Perspective center—The point of origin or termination of bundles of perspective rays. In photography, the rear node of the lens is the perspective center of the photograph, and the front node of the lens is the perspective center of the object.

Perspective grid—A network of lines drawn or superimposed on a photograph, which represents the perspective of a systematic network of lines on the ground or datum plane.

Perspective projection—*See* Projection.

Photoangulator—A mechanical device used to convert the angle measured in an oblique plane to its projection on the horizontal plane.

Photogrammetry—The science and art of obtaining reliable measurements from photographs.

Photograph—A general term for a positive or negative picture made by a camera on plate, film or other medium.

Photograph perpendicular—The perpendicular from the interior perspective center—rear node of the lens—to the plane of the photograph.

Photomap—*See* Map.

Plane coordinates—*See* Coordinates.

Planimetry—Parts of a map which represent everything except relief; that is, works of man, and natural features such as woods and water.

Planimetric map—*See* Map.

Plotting scale—The scale at which a map is to be compiled. The scale of the multiplex model when in absolute orientation.

Plumb point—The point on the ground vertically beneath the perspective center of the camera lens.

Polyethylene terephtalate—An extremely tough, durable, and dimensionally stable plastic sheeting used as a drafting and scribing base material. It is sold commercially under the trade names of "Mylar" and "Cronar."

Positive—A photograph having the same approximate rendition of light and shade as the original subject.

Press proof—A lithographed map taken from among the first copies run on the press and used for editing purposes.

Principal distance—The perpendicular distance from the interior perspective center to the plane of a particular finished negative or print. Distance from the rear node of the lens to the principal point of a photograph.

Principal line—The trace of the principal plane upon the photograph. (*See also* Principal plane.)

Principal plane—The vertical plane through the internal perspective center containing the photograph perpendicular of an oblique photograph; that is, any photograph which is not a truly vertical photograph.

Principal point—The foot of the perpendicular from the interior perspective center to the plane of the photograph; that is, the foot of the photograph perpendicular.

Print—A photographic copy made by projec-

tion or contact printing from a photographic negative or from a transparent drawing, as in blueprinting.

Contact print—A print made with the negative or transparent drawing in contact with the sensitized surface.

Ratio print—A print the scale of which has been changed from that of the negative by photographic enlargement, reduction, or restitution.

Projection—(1) In geometry, the extension of lines or planes to intersect a given surface.
(2) The transfer of a point from one surface to a corresponding position on another surface by graphical or analytical methods.

Map projection—(1) A systematic drawing of lines on a plane surface to represent the parallels of latitude and the meridians of longitude of the earth or a section of the earth.
(2) A geometric projection on a plane surface.

Perspective projection—The projection of points by straight lines drawn through them from some given point to an intersection with the plane of projection.

Orthographic projection—A perspective projection of points by straight lines from a point of projection at an infinite distance from the plane of the drawing.

Projection distance—In the multiplex projector, the distance from the front node of the projector lens to the plane of projection.

Radial—A line or direction from the radial center to any point on a photograph. The radial center for truly vertical photographs is the principal point.

Radial triangulation—See Triangulation.

Ratio print—See Print.

Reconnaissance—A general examination or survey of a region with reference to its main features, usually as a preliminary to a more detailed survey.

Rectangular coordinates—See Coordinates.

Rectification—The process of projecting a tilted or oblique photograph to a horizontal reference plane, the angular relation between the photograph and the plane being determined from known or estimated data.

Rectified photograph—A photographic print made by projection in a rectifying printer which has been properly set for rectification.

Relative orientation—See Orientation.

Relief—The variation in the height of the earth's surface. The third dimension in depth perception.

Relief model—A general category which denotes any three dimensional representation of an object or geographic area, modeled in any size or medium. Subordinate categories —not interchangeable with the general term are:

Terrain model—Any three dimensional model of a geographic area constructed to scale. A specific and distinct type of the terrain model is the plastic relief map; however, through extended use, it has become classified as a separate product.

Plastic relief map—A topographic map printed on plastic and molded into a three-dimensional form. The plastic medium is generally formed by heat and vacuum over a terrain model to achieve the three-dimensional representation.

Reproduction—The summation of all the processes involved in printing copies from an original drawing.

Rhumb line—A line which crosses successive meridians at a constant angle, also loxodrome. The Mercator is the only map projection on which a rhumb line is represented by a straight line.

Scale—The ratio of distance measured on a map to the corresponding distance on the ground. Different from representative fraction only in that scale can be expressed in other than fractional form; that is, such as an equation with different units of measurement on each side.

Scaling—(1) Alteration of the scale in photogrammetric triangulation to bring the model into agreement with a plot of horizontal control.
(2) Fitting a stereoscopic model to a horizontal control plot. A step in *absolute orientation.*

Sepia print—A photographic reproduction obtained by the use of a surface with a light sensitive iron and silver salt in a gelatin coating, which after exposure to brilliant light will turn brown when developed. Also known as Van Dyke.

Side lap—*See* Overlap.

Slotted templet—*See* Templet.

Spatial model—A stereoscopic model. (*See also* Stereoscopic model.)

Sphere—A body of space bounded by one surface, all points of which are equally distant from a point within called its center.

Stereoscopy—The science and art which deal with stereoscopic effects and the methods by which they are reproduced.

Stereoscopic fusion—That mental process which combines two perspective images of an object on the retinas of the eyes to give a mental impression of a three-dimensional model.

Stereoscopic image or stereoscopic model—That mental impression of a three-dimensional model which results from stereoscopic fusion of a stereoscopic pair.

Stereoscopic pair—Two photographs of the same area taken from different camera stations in such a manner as to afford stereoscopic vision. Also called a *stereogram.*

Stereoscopic vision—That particular application of binocular vision which enables the observer to view an object, or two different perspectives of an object—as two photographs of the same image taken from different camera stations—and to obtain therefrom the mental impression of a three-dimensional model.

Stereogram—*See* Stereoscopic pair.

Stereoscope—An optical instrument for assisting the observer in obtaining stereoscopic vision from two properly prepared photographs.

Stick-up—A gum-backed opaque or wax-backed transparent material, on which names, numbers, or symbols are printed for the purpose of imposing them on the drafted copy, thereby eliminating the necessity of handdrafting.

Stic-pat—An adhesive-backed cellophane on which map symbols are printed.

Strategic map—*See* Map.

Survey—The act or operation of making measurements for determining the relative positions of points on or beneath the earth's surface.

Aerial survey—(1) A survey utilizing aerial photographs as part of the surveying operations.

(2) The taking of aerial photographs for surveying purposes.

Tactical map—*See* Map.

Templet—A substitute for a photograph used in radial triangulation, on which is recorded the radial center and the radial lines taken from the photograph.

Slotted templet—A mechanical templet on which the radial are represented by slots cut in a sheet of cardboard, metal, or other material.

Mechanical-arm templet or slotted-arm templet—A templet which is formed by attaching slotted steel arms, which represent the radials to a center core.

Terrain—An area of ground considered as to its extent and topography.

Tilt—The angle between the photograph perpendicular and a vertical through the air station.

Tip and tilt—In practical photogrammetry, the X and Y components of absolute tilt are referred to as tilt and tip, respectively; that is, *tip* is the rotation of a photograph about the Y-axis or the axis perpendicular to the line of flight, and *tilt* is that about the X-axis or the axis parallel to the line of flight.

Topography—The features of the actual surface of the earth considered collectively as to form.

Topographic map—*See* Map.

Traverse—A method of surveying whereby the lengths and directions of lines connecting a series of stations are measured.

Triangulation:

Aerial triangulation—The determination of relative or absolute positions of different points on the earth's surface by utilizing aerial photography.

Multiplex triangulation—A stereophotogrammetric method of aerial triangulation utilizing successive stereoscopic images from overlapping aerial photographs in the multiplex projectors for the location of points, imaged on the photographs, in their correct relative position to one another.

Radial triangulation—A photogrammetric method of aerial triangulation, either analytic or graphic, utilizing overlapping vertical, nearly vertical, or oblique aerial photographs for the location of

points, imaged on the photographs, in their correct relative position to one another.

Trig data—*See* paragraph 12.

True horizon—*See* Horizon.

Uncontrolled mosaic—*See* Mosaic.

Van Dyke print—*See* Sepia print.

Vertical control—*See* Control.

Vertical-control point—A control point in a vertical control system. (*See also* Control point.)

Vertical parallax—*See* Parallax.

Vertical photograph—An aerial photograph made with the camera axis vertical or as nearly vertical as practicable.

Vinylite—A synthetic resin or plastic material, from 0.005 inch to 1/8 inch thick in increments of 0.0025 inch. It differs completely from acetate both in composition and the method used to produce it.

Zip-a-tone—Adhesive-backed cellophane on which symbols for maps are printed. Zip-a-tone may be cut in any desired size or shape and applied to drawings. (*See also* Stic-pat.)

INDEX

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For explanation of abbreviations used, see AR 320-50.

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